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VELOCITY PROFILE, SKIN-FRICTION BALANCE AND HEAT-TRANSFER MEASUREMENTS OF THE TURBULENT BOUNDARY LAYER AT MACH 5 AND ZERO-PRESSURE GRADIENT

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UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

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ABSTRACT: The results of a detailed experimental investigation of a two-dimensional turbulent boundary layer at zero-pressure gradient are presented. The studies were made at the free-stream Mach number of 5, momentum-thickness Reynolds number from 4800 to 56,000 and wall-to-adiabatic-wall temperature ratios from 0.5 to 1.0. The data are in analytical terms of velocity profile, temperature profile, law-of-the-wall, velocity-defect law and incompressible form factor. Comparisons of local skin-friction coefficients obtained by four different experimental methods are shown. An empirical equation was derived from the shear-balance data to calculate the friction coefficient from known values of Mach number, heat transfer and Reynolds number.

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Velocity Profile, Skin-Friction Balance and Heat-Transfer Measurements of the Turbulent Boundary Layer at Mach 5 and Zero-Pressure Gradient

This report presents the results of an extensive investigation of a two-dimensional turbulent boundary layer at Mach 5 with moderate heat transfer in the NOL Boundary Layer Channel. The work was performed under the sponsorship of the Naval Air Systems Command, Task No. A32 320 148/292 1/R009-02-04.

The authors wish to acknowledge the support and assistance of the Aerophysics Division of the U. S. Naval Ordnance Laboratory and in particular, wish to thank Mrs. C. D. Piper and Mr. D. L. Brott for their assistance in obtaining and reducing the data; and Messrs. F. W. Brown and F. C. Kemerer for the efficient operation of the facility and preparation of instrumentation.

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Commander

L. H. Schindel

L. H. SCHINDEL
By direction

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LIST OF SYMBOLS

C_{f_B} = local skin-friction coefficient based on balance data

C_{f_H} = local skin-friction coefficient based on heat-transfer data

c_f = local skin-friction coefficient

D = defined in Fig. 10

H_{inc} = incompressible form factor δ_i^*/θ_i

M = Mach number

n = velocity power-profile exponent

p_o = tunnel supply pressure

$\dot{q}$ = heat-transfer rate

Re_θ = momentum-thickness Reynolds number

St = Stanton number

T = temperature

$\bar{T}$ = as defined in Fig. 8

T_{aw} = adiabatic wall temperature

T_o = tunnel supply temperature

T_t = local stagnation temperature

T_{t_δ} = local stagnation temperature at outer edge of boundary layer

T_w = wall temperature

T_δ = temperature at outer edge of boundary layer

u = velocity component in the x direction

u_δ = velocity at the outer edge of boundary layer

u^* = shear velocity from shear-balance data $\sqrt{\tau_b/\rho_w}$

u^+ = nondimensional velocity = $\frac{u}{u^*}$

$\bar{x}$ = nominal axial distance in flow direction measured from nozzle throat

LIST OF SYMBOLS

y = distance normal to plate surface

y^+ = nondimensional distance from surface = $\frac{u^* y}{\nu_w}$

β = a parameter = $T_\delta - T_w / T_{t_\delta} - T_w$

δ = boundary-layer thickness

δ^* = displacement thickness

δ_i^* = incompressible displacement thickness

θ = momentum thickness

θ_i = incompressible momentum thickness

ν_w = kinematic viscosity at wall temperature

ρ_w = density at wall temperature

τ_b = shear force measured by shear balance

INTRODUCTION

The empirical nature of compressible turbulent boundary-layer theories necessitates high-quality experimental data upon which to base their formulations. Experimental studies of the boundary layer in recent years generally employ techniques such as probing with pressure and temperature probes to define the velocity and density profiles from which the local skin friction can be inferred; direct measurement of the local shear force on a floating element; and various transient and steady-state heat-transfer techniques to measure the heat transfer to the surface. The accuracy in profile measurements is limited by the smallness of the boundary-layer thickness and the relatively large probe sizes. The inference of wall friction from the velocity gradient at the wall can very easily be swayed by errors due to the effect of probe-wall interference. Floating element balances, which have been used very successfully in adiabatic-wall flows, are not as widely used in flows with high heat transfers. In flows with heat transfer, usually profile or heat-transfer measurements are used to compute the friction drag. In the application of the latter, Reynolds analogy is assumed.

The present paper presents the results of employing four different experimental techniques to obtain the friction coefficient in a compressible turbulent boundary layer with heat transfer. These are: skin-friction balance, measurements inferred from velocity and temperature gradients, and local heat-transfer measurements. Correlation of the profile and friction-coefficient data with recent empirical methods are presented.

In addition, the results of detailed measurements of the velocity and temperature profiles are presented. Analysis of the data in terms of velocity-power profile, law-of-the-wall, velocity-defect law and incompressible form factor are given.

EXPERIMENTAL PROCEDURE AND INSTRUMENTATION

The experiments were conducted in the U. S. Naval Ordnance Laboratory's Boundary Layer Channel at tunnel supply pressures between 1 and 10 atmospheres and supply temperatures between 580°R and 1210°R. The momentum-thickness Reynolds number varied from 4800 to 56,000 and wall to adiabatic-wall temperature ratio from 0.5 to 1.0. These temperature ratios were attained by varying the supply temperature and maintaining the wall temperature relatively constant. The main component of the facility is the two-dimensional supersonic nozzle illustrated in Figure 1. One wall of the nozzle is a flat plate and the opposite wall is a flexible plate which may be adjusted to give flow Mach numbers between 3 and 7 at the nozzle exit. For the present investigations the plate contour was

adjusted to prescribe a Mach 5 uniform flow over the flat plate beginning at 55 inches downstream from the nozzle throat. The operating envelope and the Reynolds number per foot capability at the Mach 5 setting are shown in Figures 2 and 3, respectively. Further details on the Channel and its performance are given in Reference (1).

The model used for boundary-layer investigations is the nozzle flat plate. The plate, made of stainless steel, and internally water cooled, is 8 feet long and tapered from 12 inches wide at the nozzle throat to 13.5 inches at the exit. Instrumentation ports, 1.875 inches in diameter, are provided along the center of the plate about every 12 inches apart starting 24 inches downstream of the nozzle throat. For the present investigation the ports located at 48, 60, 72 and 94 inches from the throat were used. Initial nozzle-design calculations using the methods of References (2), (3), and (4) and Stanton-probe measurements indicate the boundary layer to be turbulent at these locations for the operating range described. Typical boundary-layer thicknesses along the plate range from 2 to 4 inches.

The boundary-layer profile surveys were made by traversing independently a Pitot pressure probe and an equilibrium conical temperature probe across the boundary layer. Each probe was aligned with the probe tip located 2.75 inches upstream of the center of the instrumentation port. Each traverse was made from the free stream toward the plate with maximum probe movement of 3.75 inches. The speed of traverse varied during the run to insure that the probe had reached equilibrium conditions.

The profile data are recorded automatically and continuously on NOL's PADRE which is described in Reference (5). This unit provides seven channels with servo-systems and direct digital conversion to permit simultaneous sensing and recording of the data directly on IBM cards.

Pitot-pressure probes were made of 0.125-inch diameter stainless-steel tubing flattened at the tip to a rectangular opening of 0.016 x 0.100 inch. The local Mach number was computed from the Rayleigh Pitot tube formula using the measured Pitot and wall-static pressures.

The basic design of the equilibrium conical temperature probe is described in Reference (6). Essentially the equilibrium temperature of a sharp 10-degree platinum cone was measured by a thermocouple mounted onto its 0.050-inch diameter base. The cone was supported at its base by a 0.050-inch diameter, 0.5-inch long aluminum oxide tube, which also served to insulate the cone from the probe support mechanism. The measured cone temperature together with the measured local Mach number and cone tables provided the necessary information to calculate the local stagnation and static temperatures. A cone recovery factor equal to the square root of the Prandtl number was assumed, based on the cone equilibrium temperature.

The local velocity distribution was computed from the measured Mach number and temperature distributions. In the region of uniform flow, the experimental free-stream edge of the boundary layer is selected as the location where the slope of the velocity gradient becomes zero, $\frac{du}{dy} = 0$. In the 48-inch station where pressure gradient exists in the free stream, the edge is selected where $\frac{du}{dy} =$ constant.

The basic design of the NOL skin-friction balance is described in Reference (7). A schematic diagram illustrating its major components is shown in Figure 4. The instrument measured directly the shear drag on a circular surface floating element mounted flush with the flat plate. The element has an area of 0.5-square-inch. The balance was water-cooled and was designed for measurements in flows with heat transfer and pressure gradient.

Heat-transfer measurements were made by measuring the equilibrium temperature distribution in a stainless-steel rod, insulated around its circumference, and mounted with the axis normal to the plate surface. Four iron-constantan thermocouples were welded to the rod at 0.25-inch intervals, measured from the end face of the rod that was mounted flush with the flat plate. The local skin-friction coefficient was computed from the temperature gradient at the surface and the Colburn form of Reynolds analogy. One-dimensional heat flow along the axis of the rod was assumed.

At the low operating supply pressure range, the boundary layer was sufficiently thick such that temperature probing in the boundary-layer sublayer provides an accurate measurement of the temperature gradient. For these cases, the heat transfer was computed as the product of the temperature gradient at the surface and the thermal conductivity of air at the surface temperature. Reynolds analogy was again used to obtain the friction coefficient.

EXPERIMENTAL RESULTS

Free-stream Pitot-pressure distributions measured with a five-finger rake as reported in Reference (1), showed the flow to be uniform within ±0.75 percent of the free-stream Mach number in the region from the 55-inch station to the end of the flat plate. Static-pressure probe surveys across the boundary layer from 0.5 to 4.0 inches above the plate were made at the 60-inch and 94-inch stations. They showed the static-pressure variation to be within ±2.3 percent of the mean value at that station. Consequently, the static pressure was assumed to be constant.

The profile measurements in terms of local Mach number, static temperature, velocity and density are listed in Table 1. Graphs of the velocity profiles are shown in Figure 5. Because of

the thicker boundary layer at the one atmosphere pressure conditions, it was possible to probe deep into the sublayer region, into the linear portion of the velocity profile. For comparison, Figure 5C shows computed velocity profiles using the numerical solution of Reference (8) for three supply temperatures. The numerical results agree reasonably well with the profile data at the lower temperature, $T_0 = 775°R$, condition but differ considerably at the two higher temperature surveys.

The dashed lines in Figure 5 show the velocity gradient deduced from the friction balance data. The balance results are also in good agreement with the profile results except at the higher temperature runs.

A portion of the outer region can be readily fitted with a power profile. The variation of the power-profile exponent with momentum-thickness Reynolds number is shown in Figure 6. The data was fitted by the method of least squares by the expression shown. The dependence of n with Re_θ appears to be independent of heat transfer.

The static temperature-velocity profiles are shown in Figure 7. A second order polynominal,

$$\frac{T}{T_\delta} = a + b \left(\frac{u}{U_\delta}\right) + c \left(\frac{u}{U_\delta}\right)^2 \qquad (1)$$

was computed using the following boundary conditions to calculate the coefficients a, b, and c:

$$y = 0,\ \frac{T}{T_\delta} = \frac{T_w}{T_\delta},\ \frac{u}{u_\delta} = 0,\ \frac{d\left(\frac{T}{T_\delta}\right)}{dy} = \frac{(T_{aw} - T_w)}{T_\delta} Pr^{1/3} \frac{d\left(\frac{u}{u_\delta}\right)}{dy}$$

$$y = \delta,\ \frac{T}{T_\delta} = 1,\ \frac{u}{u_\delta} = 1 \qquad (2)$$

Equation 1 is plotted in Figure 7. The polynomial appeared to fit the adiabatic wall temperature data satisfactorily, (see Figure 7C, $T_0 \sim 600°R$) but did not give a good fit for the other cases where $T_w/T_{aw} < 1$. For comparison the relations of Walz, Reference (9), and Crocco, Reference (10), are plotted in Figure 7B.

A widely used method of correlating temperature profile data, as suggested by the Crocco energy relation, is in terms of total temperature and velocity, see Reference (9), (11), (12), and (13). This is presented in Figure 8 together with three lines representing the Crocco equation for unit Prandtl number; the zero heat-transfer quadratic equation by Walz:

$$\bar{T} = \left(\frac{u}{u_\delta}\right)^2 \tag{3}$$

and the following expression by Danberg, Reference (11):

$$\bar{T} = \beta \left(\frac{u}{u_\delta}\right) + (1 - \beta)\left(\frac{u}{u_\delta}\right)^2 \tag{4}$$

where

$$\beta = \frac{T_{aw} - T_w}{T_{t_\delta} - T_w}$$

In general the present results follow the quadratic relation, equation (3), and are consistent with the general conclusion of References (12) and (13) that data on the nozzle wall follow the quadratic rather than the Crocco relation. However, as shown in Figure 8, the data at the lowest Reynolds number at each station show a transition from the quadratic to the Crocco within the sublayer region. This trend was verified by independent measurements with the hot-wire temperature probe, see Reference (14). It has been suggested that the upstream boundary-layer history and heat transfer to the wall can produce deviation from the linear Crocco relation. The details of this deviation and manner of its recovery need further investigation to better the understanding of turbulent boundary-layer flow.

The data in Figure 8 are presented in two groupings; for a constant heat-transfer rate where $T_w/T_{aw} = 0.73$ and for a constant tunnel supply pressure of five atmospheres. Little effect is noted at the outer region of the boundary layer due to Reynolds number variation. A systematic shift from the quadratic to the linear relation is noted as heat transfer increases or as the ratio T_w/T_{aw} decreases.

Comparisons of the profile results with the Law of the Wall and Velocity Defect Law are shown in Figures 9 and 10, respectively. The shear velocity was computed from shear balance data. The solid line in the outer turbulent zone of Figure 9 is that reported by Baronti and Libby, Reference (15), for adiabatic wall flows.

$$u^+ = 2.43 \ln(7.5\, y^+) \tag{5}$$

In the Velocity Defect Law correlation of Figure 10, the solid lines represent empirical fits by Clauser and Hama, respectively, of incompressible flow data as reported in Reference (16). The equations for these lines are:

$$\frac{u_\delta - u}{u^*} = 2.44 \ln \frac{y}{\delta} + 2.5 \text{ for } \frac{y}{\delta} \leq 0.15 \quad (6)$$

$$\frac{u_\delta - u}{u^*} = 9.6(1 - \frac{y}{\delta})^2 \text{ for } \frac{y}{\delta} > 0.15 \quad (7)$$

It appeared that the correlations of the data in both Law of the Wall and Velocity Defect Law showed a stronger dependency on heat transfer as expressed in T_w/T_{aw} ratio rather than on Reynolds number.

Correlation of the data in terms of the incompressible form factor is shown in Figure 11. The present results and also the results of Winkler-Cha, Reference (17), as shown are parallel to the Tetervin-Lin fit of incompressible flow data, see Reference (18). The dotted line was drawn parallel to the Tetervin-Lin curve but displaced to go through the present data. The third line drawn was obtained by use of power profiles and Figure 6.

where $$H_{inc} = \frac{\delta^*_{inc}}{\theta_{inc}} = \frac{2}{n} + 1 \quad (8)$$

The data did not show any trend due to heat transfer.

The skin-friction coefficient obtained by the four experimental methods at the four test stations are shown in Figure 12. For comparison, predictions shown were those of Spalding-Chi, Reference (19); Falkner and Blasius, Reference (20); Persh, Reference (21); and Winkler-Cha, Reference (17). These predicted values represented by the lines were computed for $T_w/T_{aw} = .73$ where most of the experimental data were taken. Generally, the shear balance data are about 20 percent lower than the widely accepted prediction of Spalding-Chi. The velocity profile data showed more scatter than the balance data, reflecting the difficulty of obtaining accurate friction coefficients from profile measurements.

Friction coefficients obtained from heat-transfer data as shown in Figures 12B and 12C and tabulated in Table 2 indicate a marked deviation from those based on balance measurements with increasing Reynolds number. This may be a consequence of assuming a constant turbulent flow recovery factor of 0.89 and the acceptance of the Colburn form of Reynolds analogy.

$$\frac{2St}{c_f} = Pr^{-2/3} \quad (9)$$

The present data show a Reynolds number effect on the Reynolds analogy factor which is stronger than indicated by Tetervin, Reference (22). This is shown in Figure 13. Figure 14 is a comparison of the present results with those of Danberg, Reference (11) for similar heat-transfer range. It appears that further studies are needed in this area to relate heat transfer to skin friction.

The balance data from the four measuring stations for T_w/T_{aw} = .73 are replotted in Figure 15. Very good agreement was obtained between the measurements at the 60, 72, and 94-inch stations. The measurements at the 48-inch station were higher than the others because they were in the pressure drop region of the nozzle. The good agreement of the data at the three downstream stations indicated that pressure gradient history at the upstream end of the plate was "forgotten" and the local flow was similar to zero pressure gradient flat plate flow. The data from the downstream three measuring stations were fitted by the least-square method to obtain the following relation:

$$c_f = 0.0211\ Re_\theta^{-0.10} \tag{11}$$

which fits the experimental data to 7.5 percent. In contrast, the similar balance data at the 48-inch station, which was in the pressure drop region, resulted in a parallel line with higher friction coefficients.

Further analysis of the experimental data in Figure 12 indicated that at decreasing values of T_w/T_{aw}, both the balance and heat-transfer results showed c_f to increase slightly whereas the velocity-profile measurements showed the opposite trend. It can be speculated that the cooling of the wall can introduce curvature of the velocity profile very near the wall as illustrated in Figure 16. Figure 16A represents a typical temperature distribution in the boundary layer with wall cooling. If it is assumed that the coefficient of viscosity is proportional to the temperature and the shear is constant some distance past the peak of the temperature curve then the velocity gradient must complement the temperature distribution as shown in Figure 16B for the equation shown in the figure to be true. Integrating the curve of Figure 16B will result in the velocity distribution of Figure 16C where a hump would exist near the wall. The interpretation of the data outside this hump would lead to the slope shown by the dotted line and result in a lower value of the shear force. Unfortunately the size of probes used in the present investigation made it difficult to distinguish between probe interference and temperature distortion of the boundary layer. Numerical calculations of the turbulent boundary layer by the method of Tetervin, Reference (8) add some support to this theory. The calculations were made for

Mach 10 flow with three assumed values of T_w/T_{aw} and is shown in Figure 17. Although no hump appeared, the curved portion of the velocity profile extends closer to the wall as T_w/T_{aw} is decreased and consequently the error in estimating the slope of the velocity profile at the wall when obtained by a fairing of experimental points not very near the wall becomes larger. Figure 17 indicates that the size limitation of present probing techniques renders this method of obtaining friction coefficients inaccurate for very cold walls.

Further correlation of the wall temperature effect on friction coefficients as obtained by the velocity profile technique and direct force measurement are shown in Figure 18 for one value of Reynolds number. The balance results showed a slight increase in c_f due to wall temperature and the friction coefficients were lower than predicted by the Spalding-Chi method. The velocity-profile results reflected the above analysis and were in general agreement with the results of Winkler-Cha which were based on profile measurements at T_w/T_{aw} greater than 0.61.

The present data was fitted by the method of least squares by the equation shown in Figure 18. The basic form of the equation was adapted from Reference (17) and the coefficient and exponents for the heat transfer and Reynolds number terms adjusted to fit the present data. The Mach number dependency term, (T_o/T_δ), was carried over from Reference (17). This equation describes the present data to within 6.6 percent as shown in Table 3.

CONCLUSION

The turbulent boundary layer in the NOL Boundary Layer Channel at Mach 5; $4800 < Re_\theta < 56{,}000$; $.48 < T_w/T_{aw} < 1.0$; was studied with pressure and temperature probes, a shear balance, and a heat-transfer gage.

The structure of the boundary layer was examined in terms of velocity and temperature profiles, law of the wall, velocity-defect law and incompressible form factor. Data was obtained to $y^+ = 1.4$; this is much closer to the wall than previously obtained. The outer portion of the velocity profile can be fitted by a power profile. A relation between power-profile exponent and momentum-thickness Reynolds number was derived. Correlation of the incompressible form factor showed similarity with subsonic flow results. An expression relating the form factor with momentum-thickness Reynolds number was given.

Local skin-friction coefficients obtained from shear-balance measurements, velocity-profile data, temperature-profile data and heat-transfer data were compared. The balance results were the most consistent of the four and were about 20 percent lower than the prediction of Spalding-Chi. Heat-transfer measurements showed

a marked disagreement with shear-balance measurements at high Reynolds numbers. The Reynolds analogy factor is strongly affected by Reynolds number. The local skin-friction coefficient as measured with shear balance and a heat-transfer gage increased slightly as T_w/T_{aw} decreased. Velocity-profile measurements indicated the opposite trend. The distortion of the velocity profile very close to the wall by heat transfer was a suggested cause. This was supported by calculations by Tetervin's method. An equation was obtained by the least-square fit of the data to compute the local friction coefficient. This equation accounts for variations in Mach number, heat transfer and Reynolds number and represents the present data to within 6.6 percent.

The data showed some evidence of the upstream boundary-layer history and the heat transfer on boundary-layer profiles. The results indicate that both the friction drag and velocity profile will quickly adjust to local flat-plate conditions while the temperature profile will retain a memory of the upstream conditions for a long time. Additional analytical and experimental studies are needed to verify these findings and to better the understanding of turbulent boundary-layer flow.

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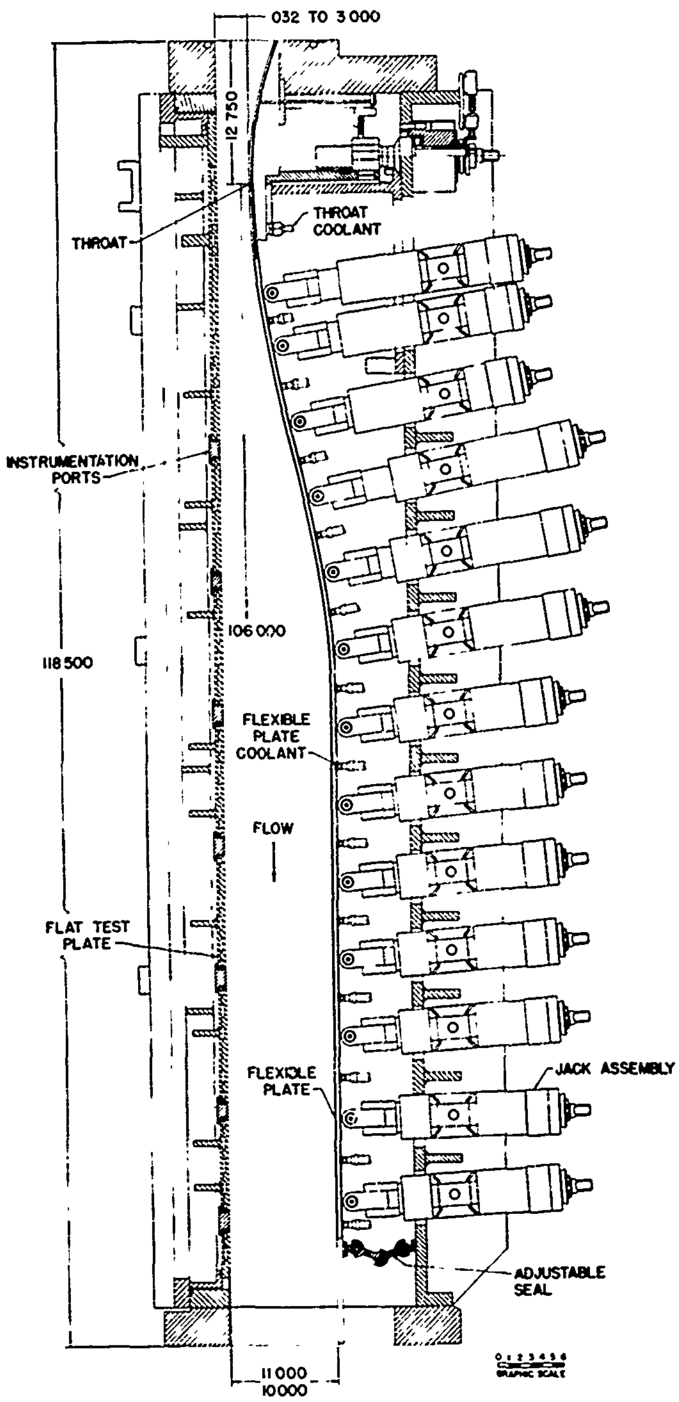


FIG. 1 BOUNDARY LAYER CHANNEL FLEXIBLE NOZZLE

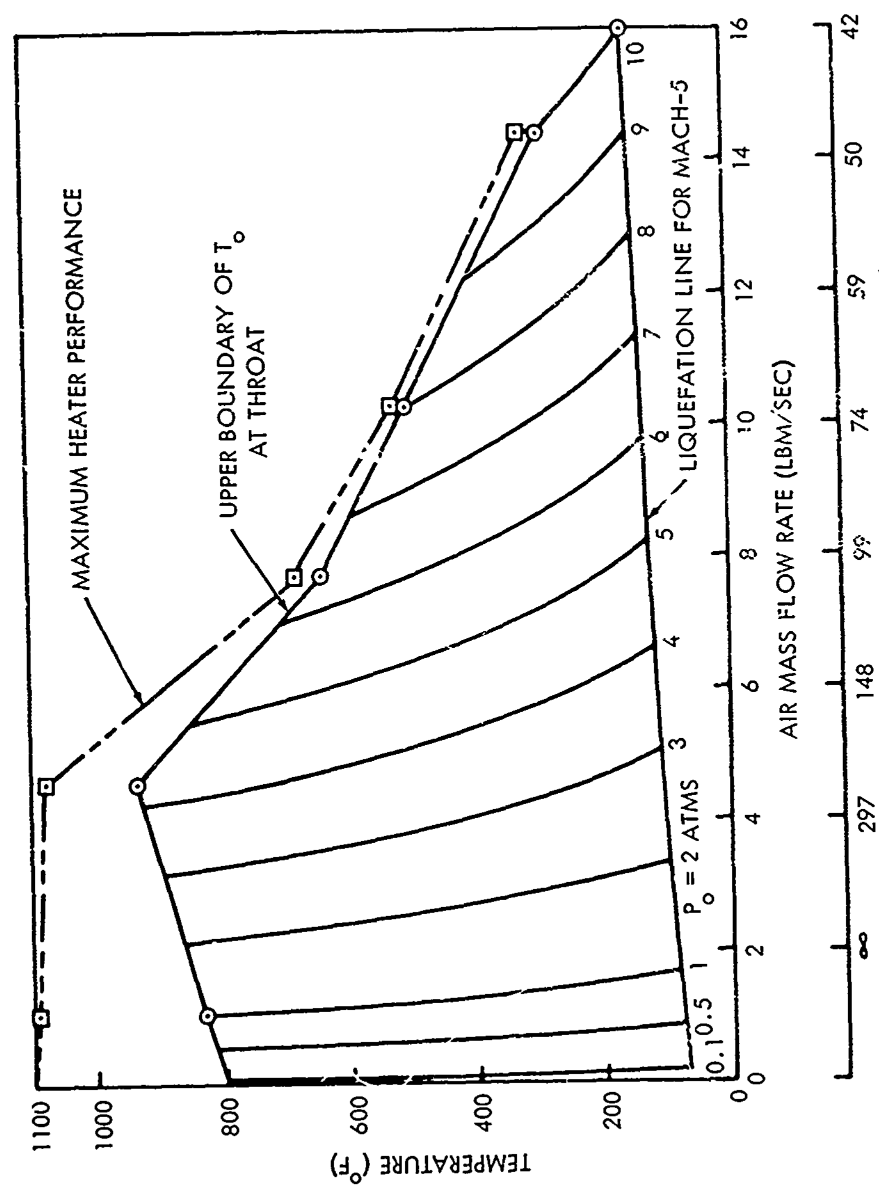


FIG. 2 OPERATING ENVELOPE FOR THE BOUNDARY LAYER CHANNEL, MACH 5

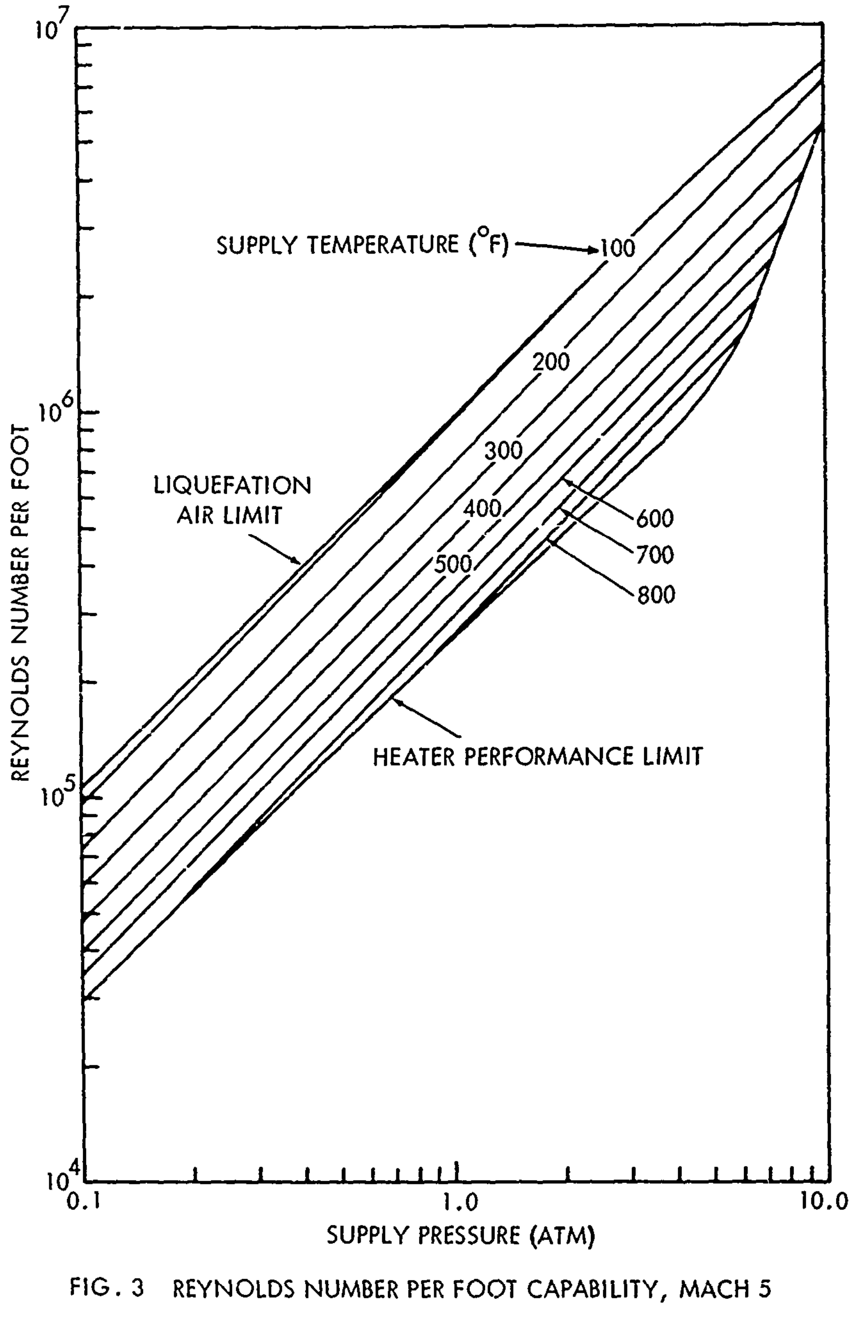


FIG. 3 REYNOLDS NUMBER PER FOOT CAPABILITY, MACH 5

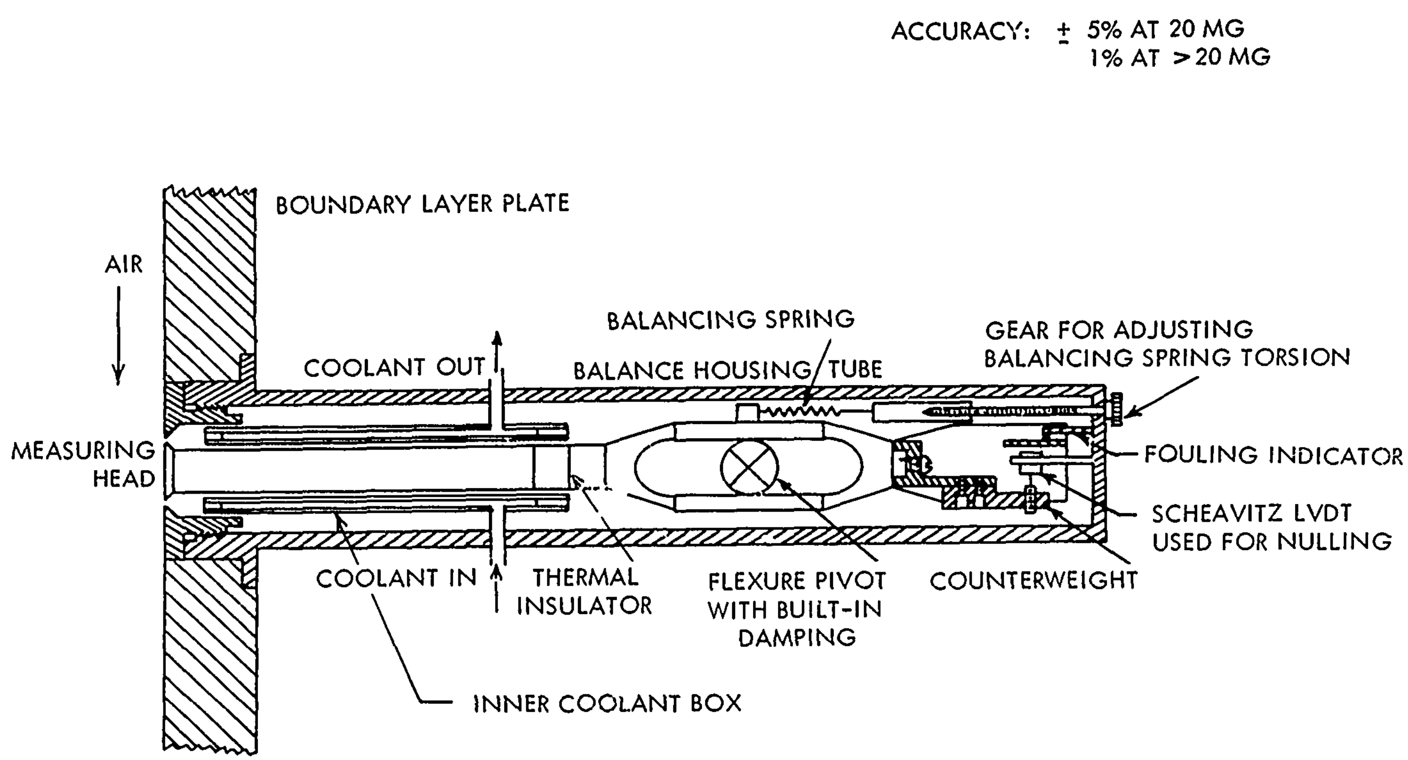


FIG. 4 SCHEMATIC SHOWING OVERALL LAYOUT OF THE SKIN FRICTION BALANCE

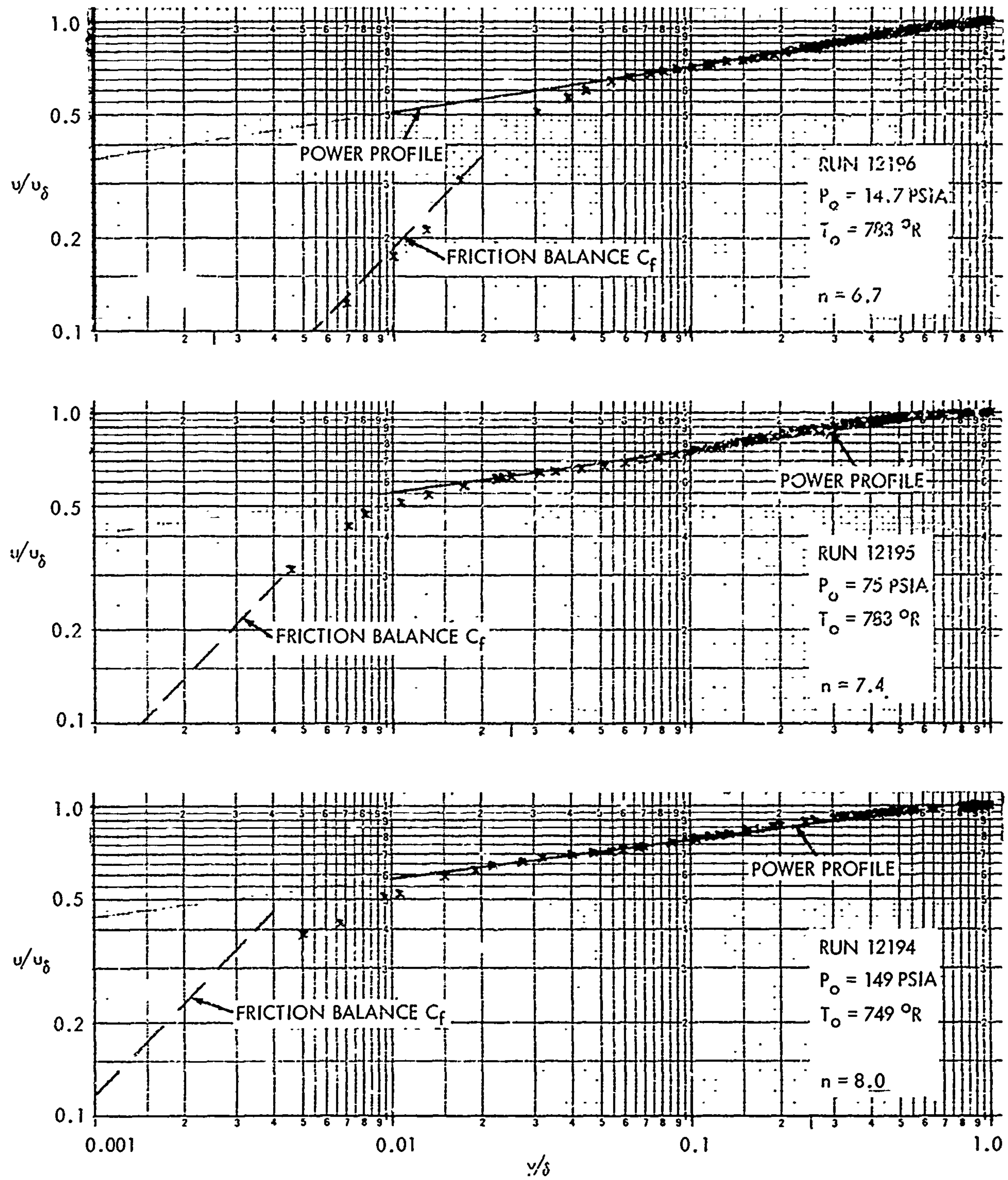


FIG. 5a VELOCITY PROFILES AT THE 48 INCH STATION

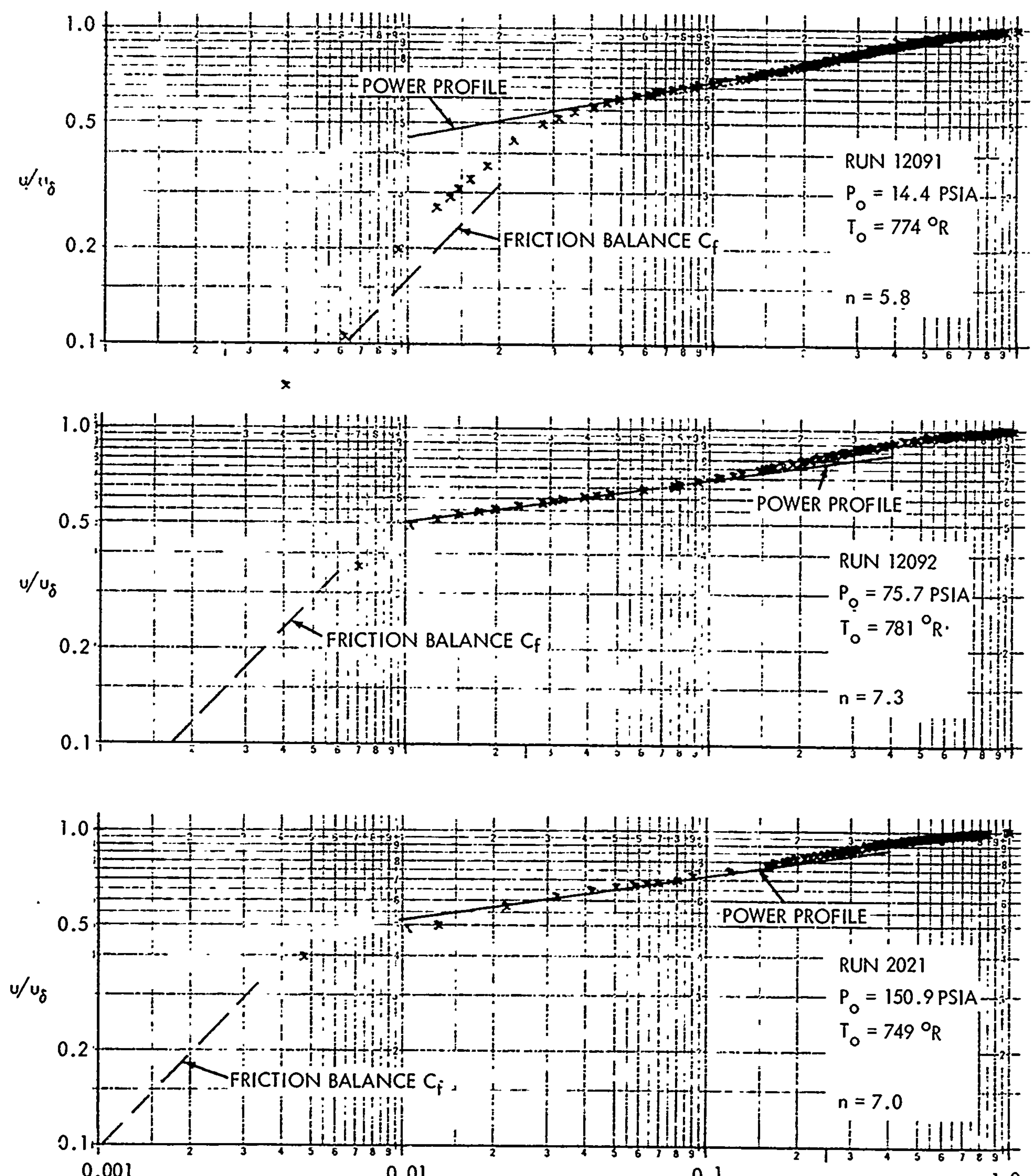
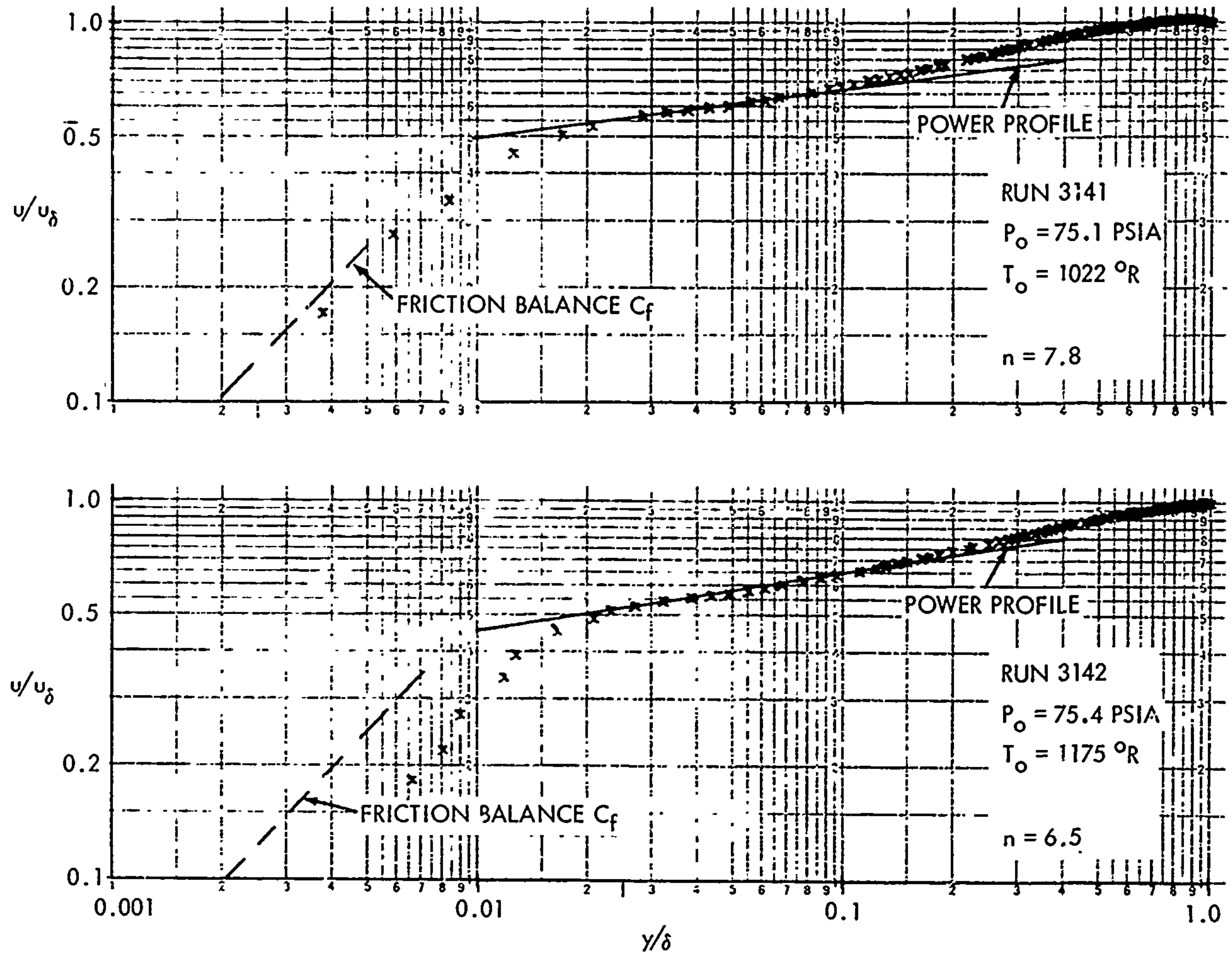


FIG. 5b (1) VELOCITY PROFILES AT THE 60 INCH STATION



1.0
0.5
u/u_δ
0.2
0.1
POWER PROFILE
RUN 3141
P_o = 75.1 PSIA
T_o = 1022 °R
n = 7.8
FRICTION BALANCE C_f
1.0
0.5
u/u_δ
0.2
0.1
POWER PROFILE
RUN 3142
P_o = 75.4 PSIA
T_o = 1175 °R
n = 6.5
FRICTION BALANCE C_f
0.001
0.01
0.1
1.0
y/δ

FIG. 5b (2) (CONT.)

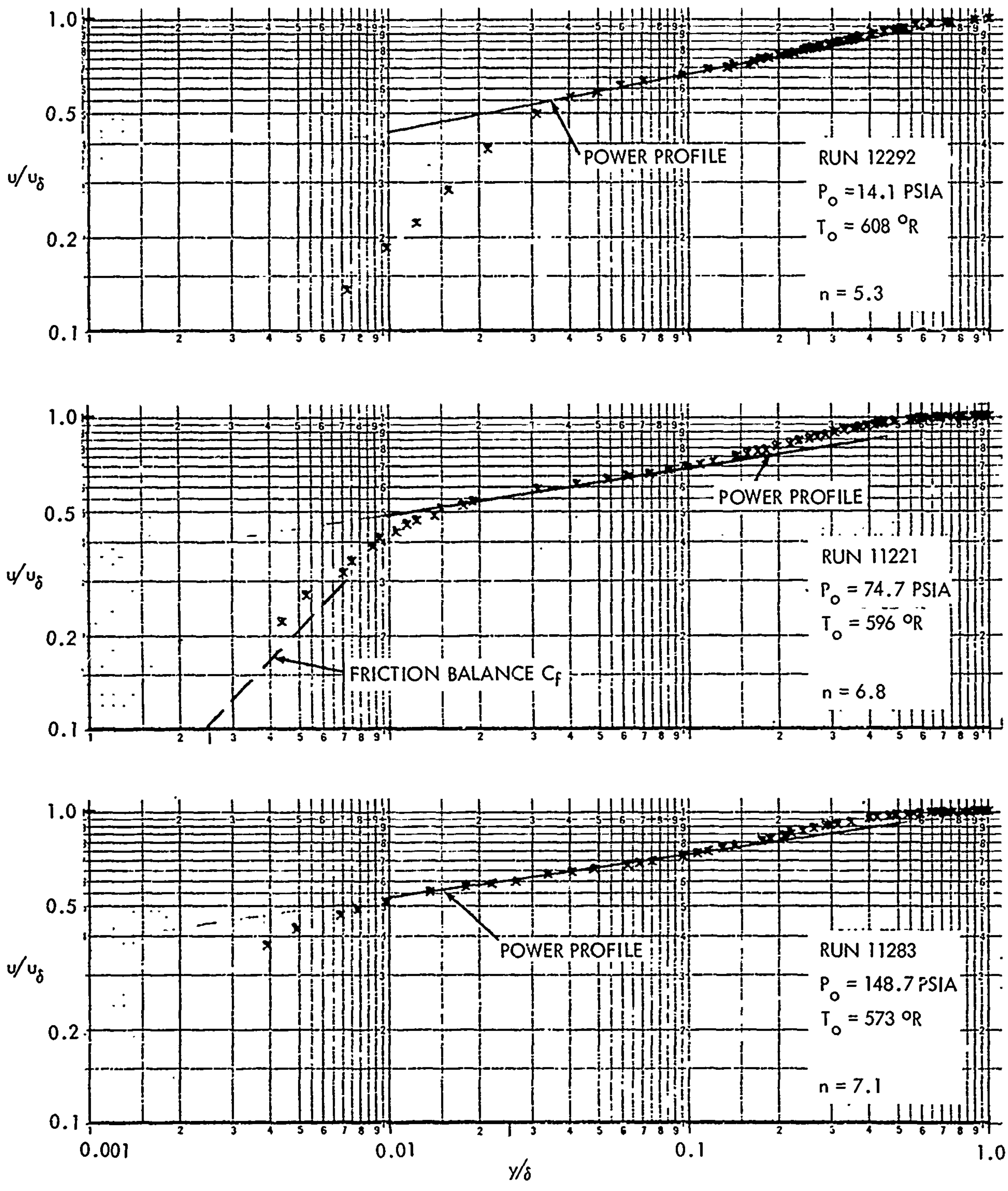
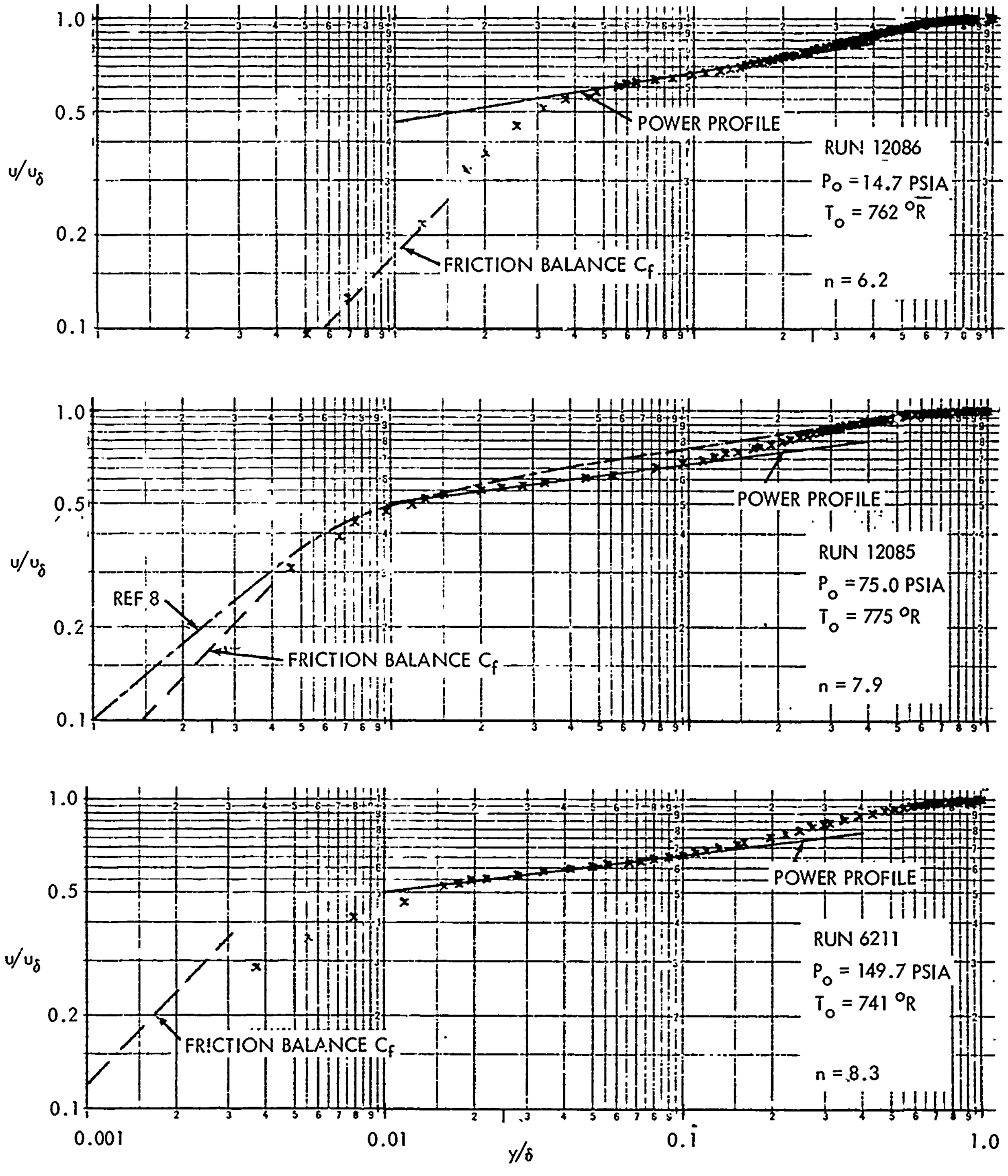
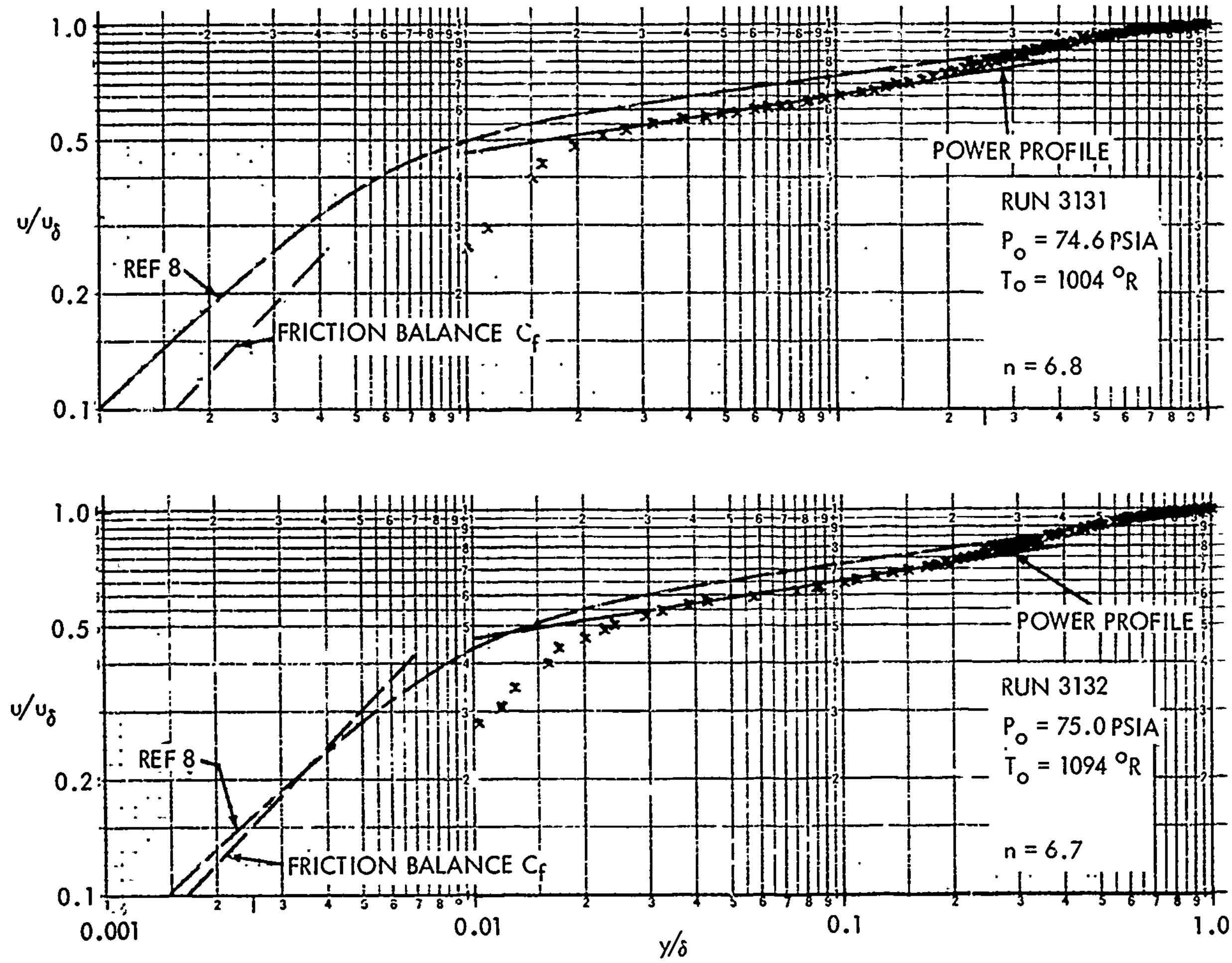


FIG. 5c(1) VELOCITY PROFILE AT THE 72 INCH STATION



1.0
0.5
0.2
0.1
u/u_δ
POWER PROFILE
RUN 12086
P_o = 14.7 PSIA
T_o = 762 °R
FRICTION BALANCE C_f
n = 6.2
1.0
0.5
0.2
0.1
u/u_δ
POWER PROFILE
RUN 12085
P_o = 75.0 PSIA
T_o = 775 °R
REF 8
FRICTION BALANCE C_f
n = 7.9
1.0
0.5
0.2
0.1
u/u_δ
POWER PROFILE
RUN 6211
P_o = 149.7 PSIA
T_o = 741 °R
FRICTION BALANCE C_f
n = 8.3
0.001
0.01
0.1
1.0
y/δ

FIG. 5c (2) (CONT.)



1.0
0.5
0.2
0.1
u/u_δ
REF 8
FRICTION BALANCE C_f
POWER PROFILE
RUN 3131
P_o = 74.6 PSIA
T_o = 1004 °R
n = 6.8
RUN 3132
P_o = 75.0 PSIA
T_o = 1094 °R
n = 6.7
0.001
0.01
0.1
1.0
y/δ

FIG. 5c (3) (CONT.)

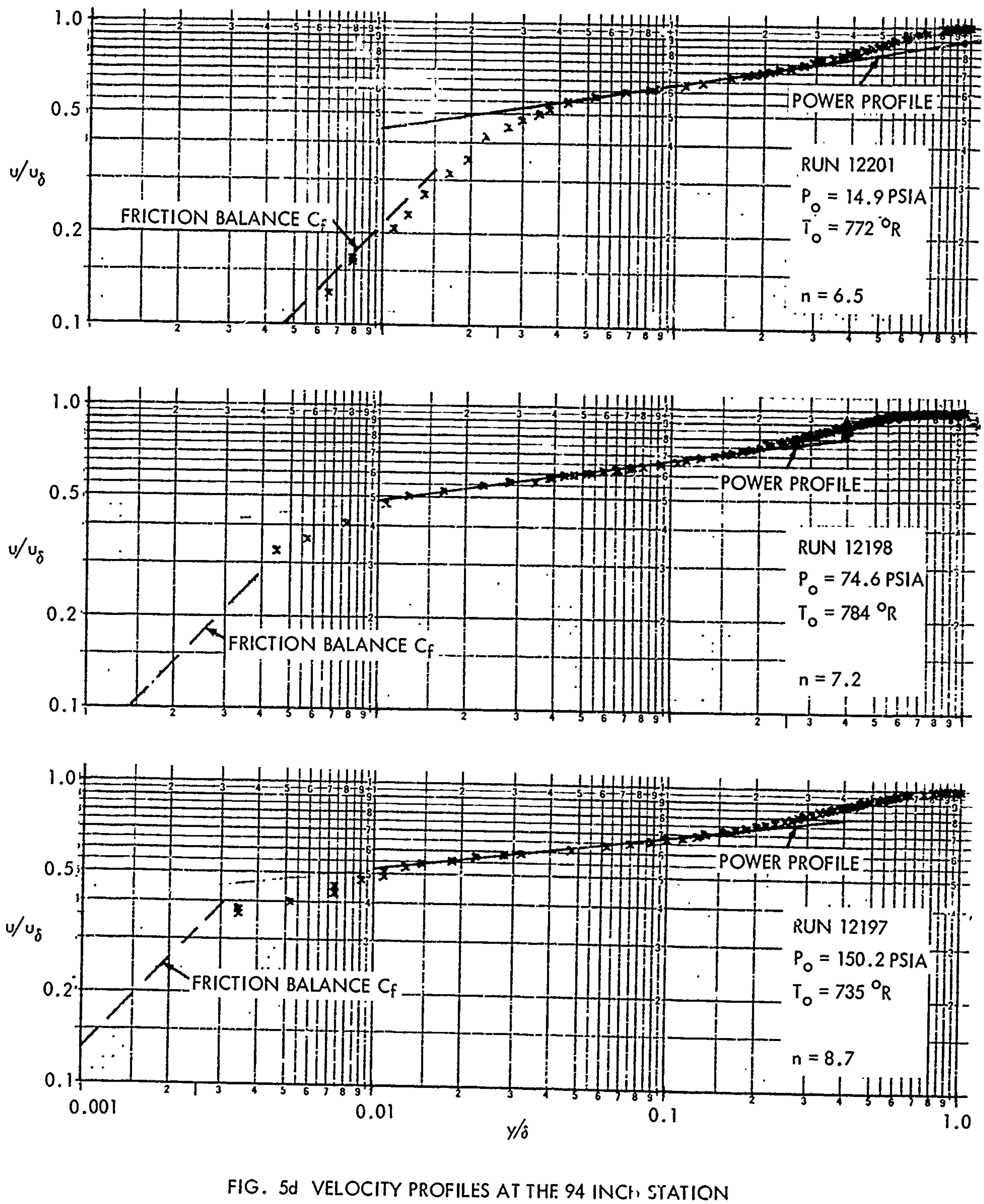


FIG. 5d VELOCITY PROFILES AT THE 94 INCH STATION

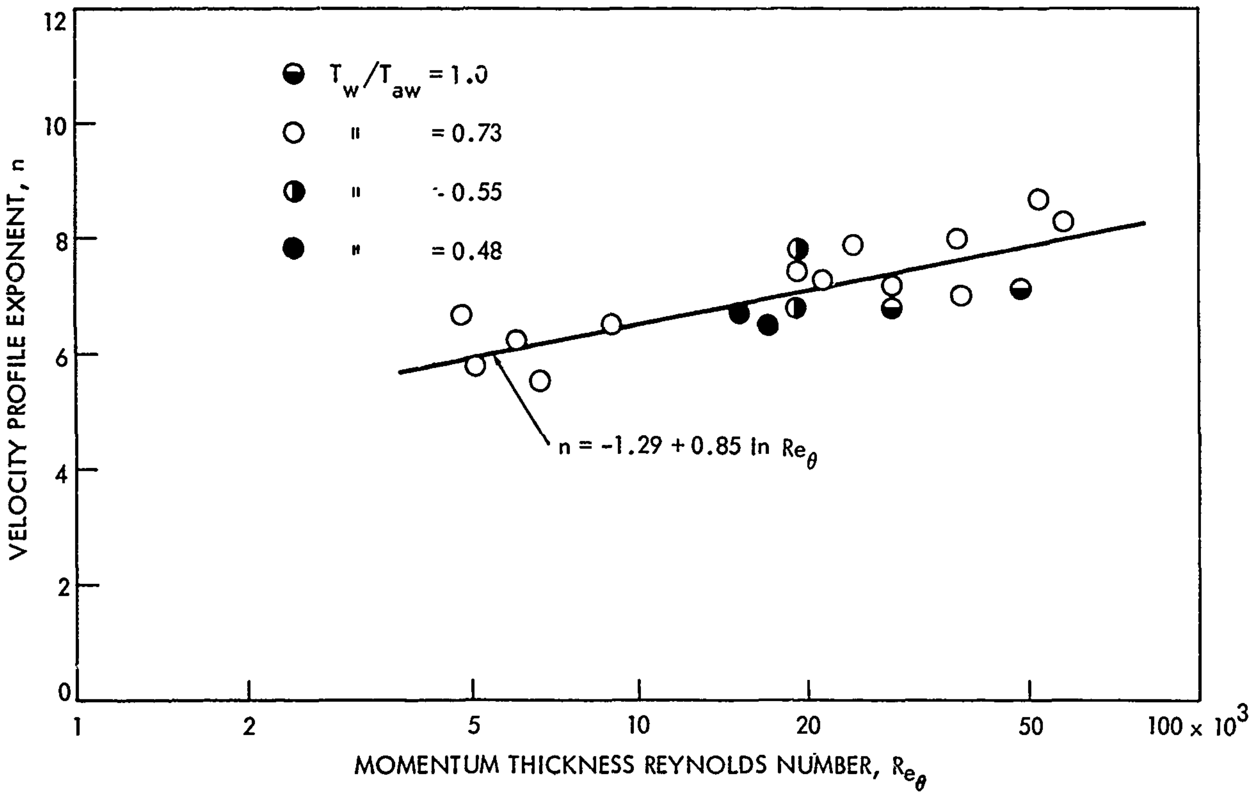


FIG. 6 VARIATION OF VELOCITY PROFILE EXPONENT WITH MOMENTUM THICKNESS REYNOLDS NUMBER

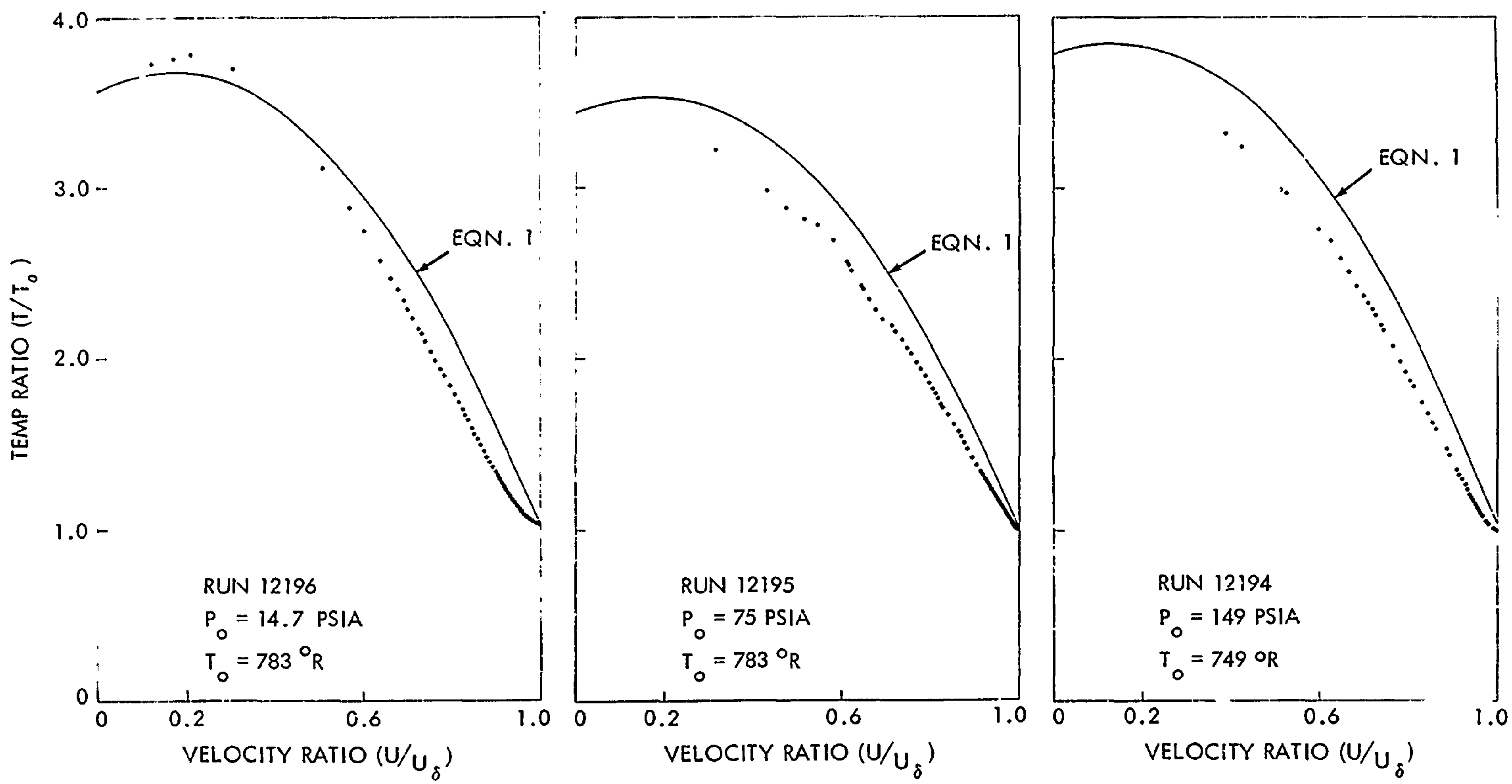


FIG. 7a STATIC TEMPERATURE - VELOCITY DISTRIBUTION AT THE 48 INCH STATION

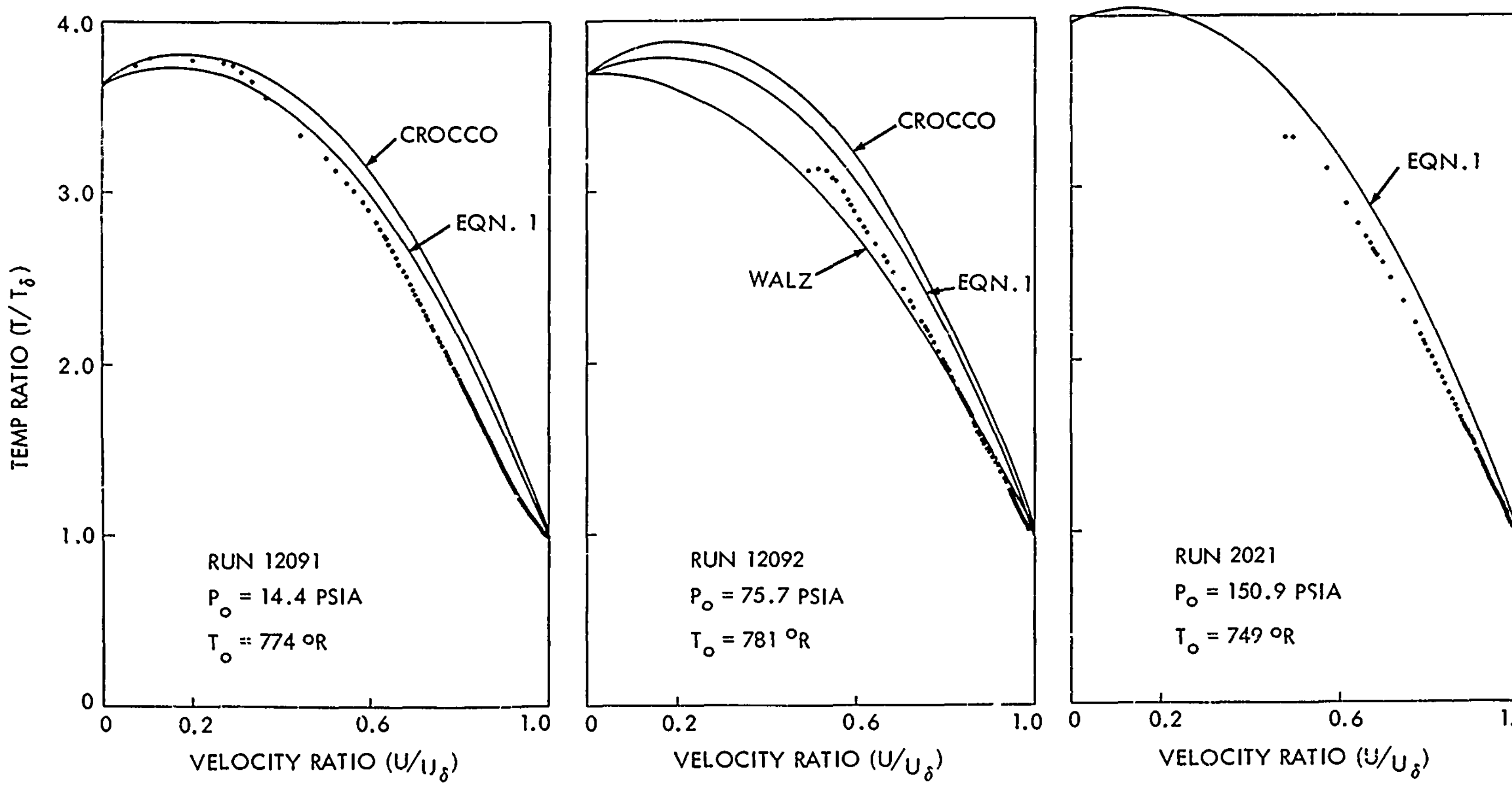


FIG. 7b(1) STATIC TEMPERATURE - VELOCITY DISTRIBUTION AT THE 60 INCH STATION

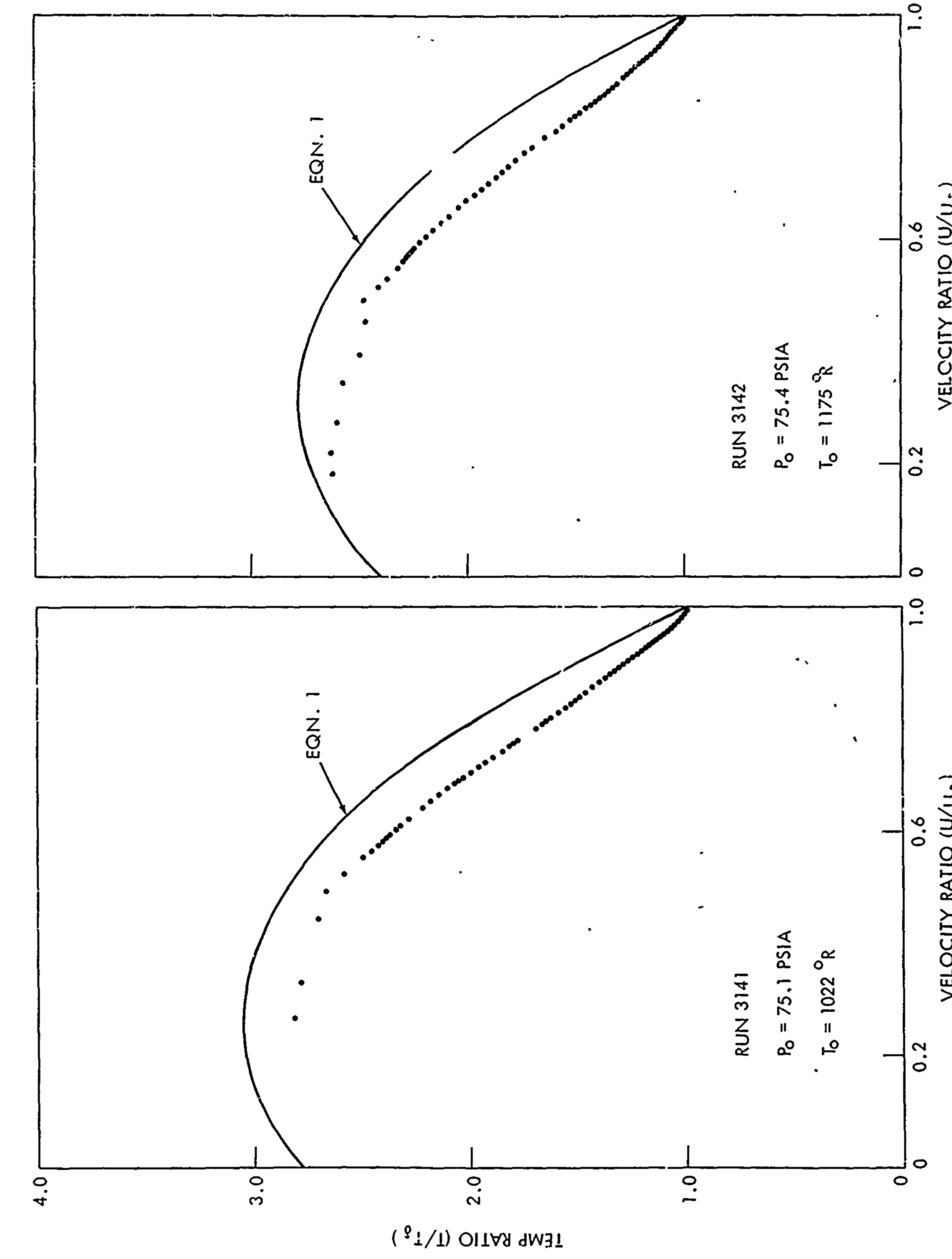

EQN. 1
RUN 3142
P_o = 75.4 PSIA
T_o = 1175 °R
EQN. 1
RUN 3141
P_o = 75.1 PSIA
T_o = 1022 °R
0
0.2
0.6
1.0
VELOCITY RATIO (U/U_δ)
4.0
3.0
2.0
1.0
TEMP RATIO (T/T_δ)

FIG. 7b (2) (CONT.)

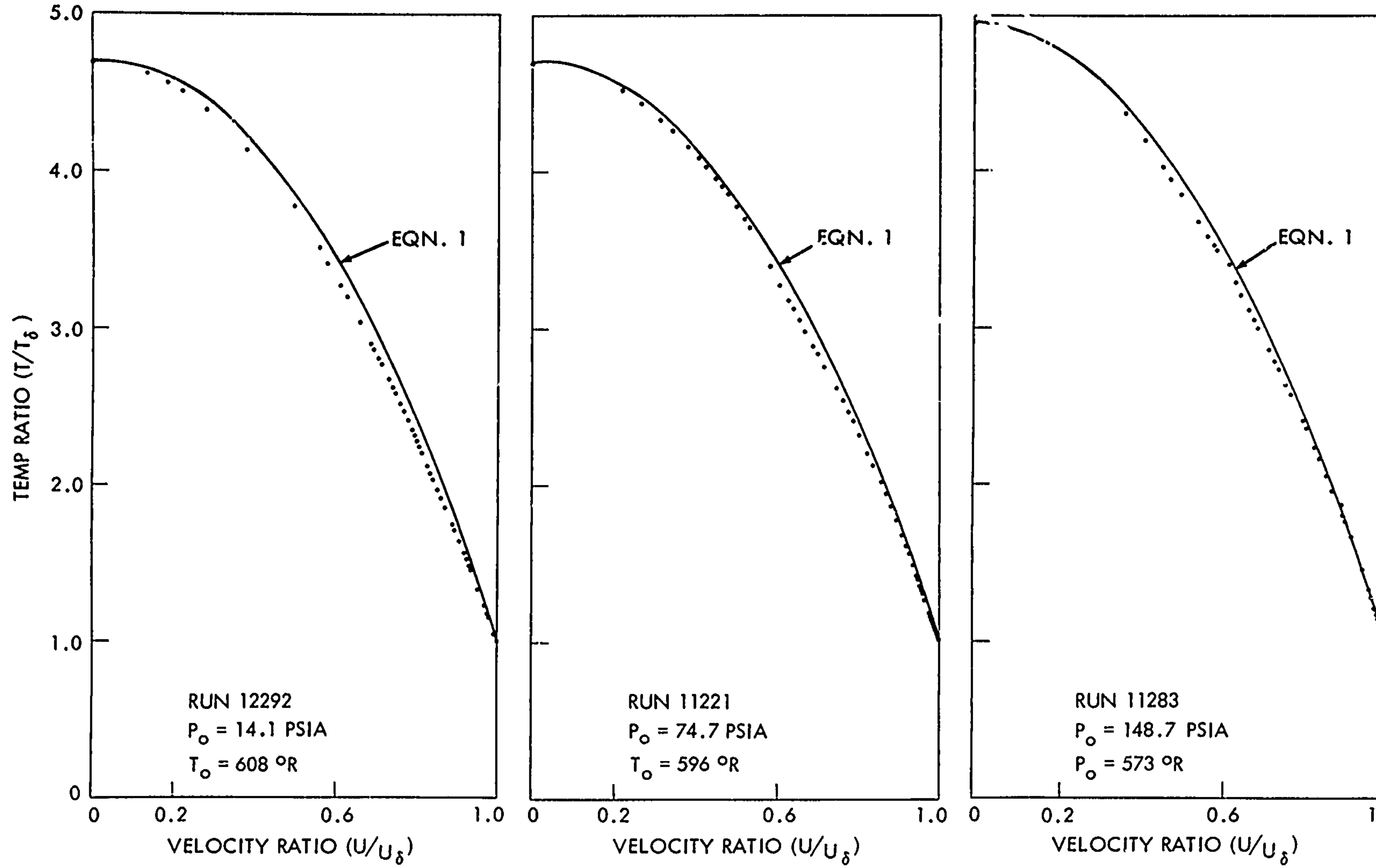
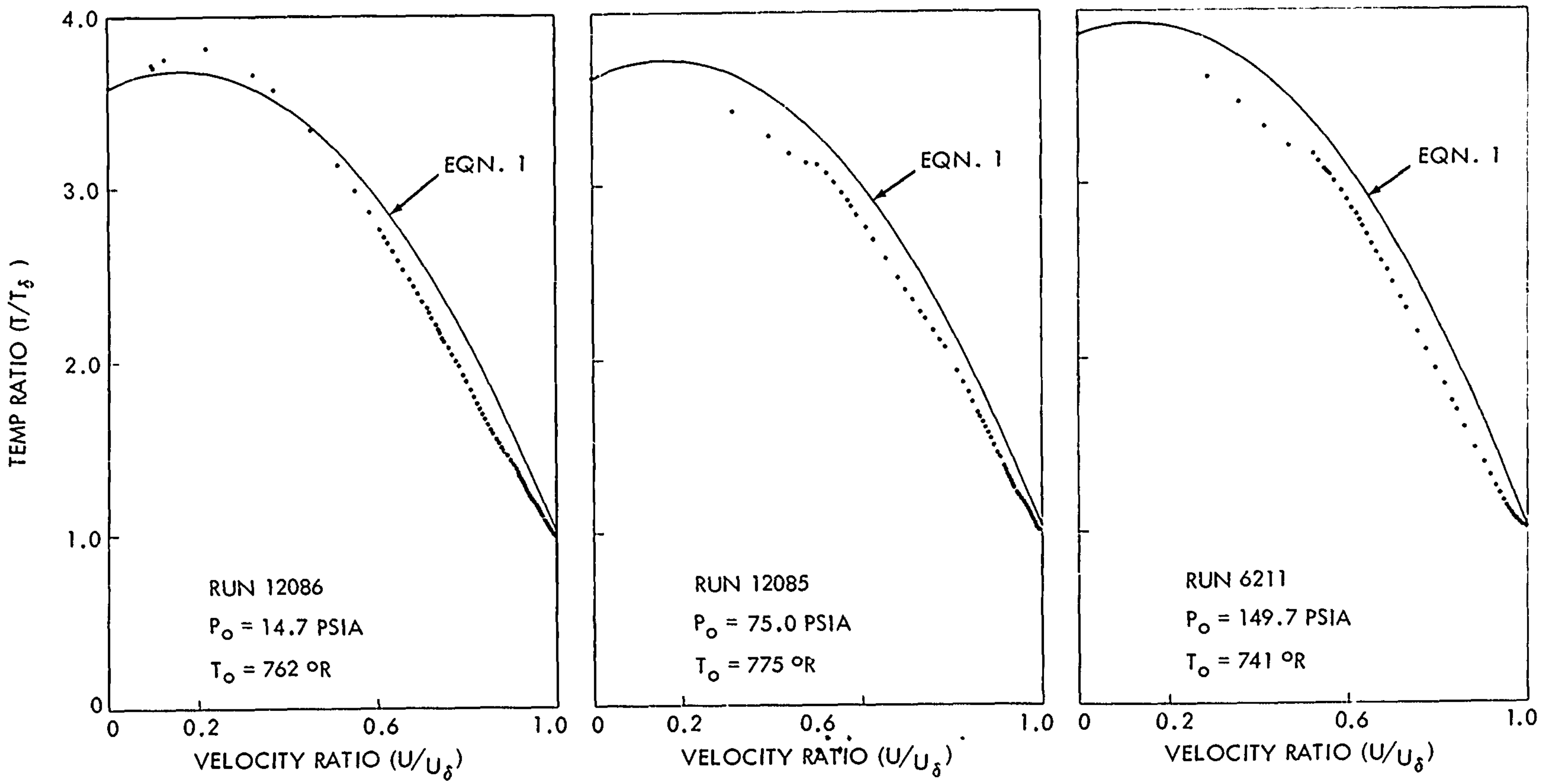


FIG. 7c (1) STATIC TEMPERATURE - VELOCITY DISTRIBUTION AT THE 72 INCH STATION



TEMP RATIO (T/Tδ)
4.0
3.0
2.0
1.0
0
EQN. 1
RUN 12086
Po = 14.7 PSIA
To = 762 °R
0
0.2
0.6
1.0
VELOCITY RATIO (U/Uδ)
EQN. 1
RUN 12085
Po = 75.0 PSIA
To = 775 °R
0
0.2
0.6
1.0
VELOCITY RATIO (U/Uδ)
EQN. 1
RUN 6211
Po = 149.7 PSIA
To = 741 °R
0
0.2
0.6
1.0
VELOCITY RATIO (U/Uδ)

FIG. 7c(2) (CONT.)

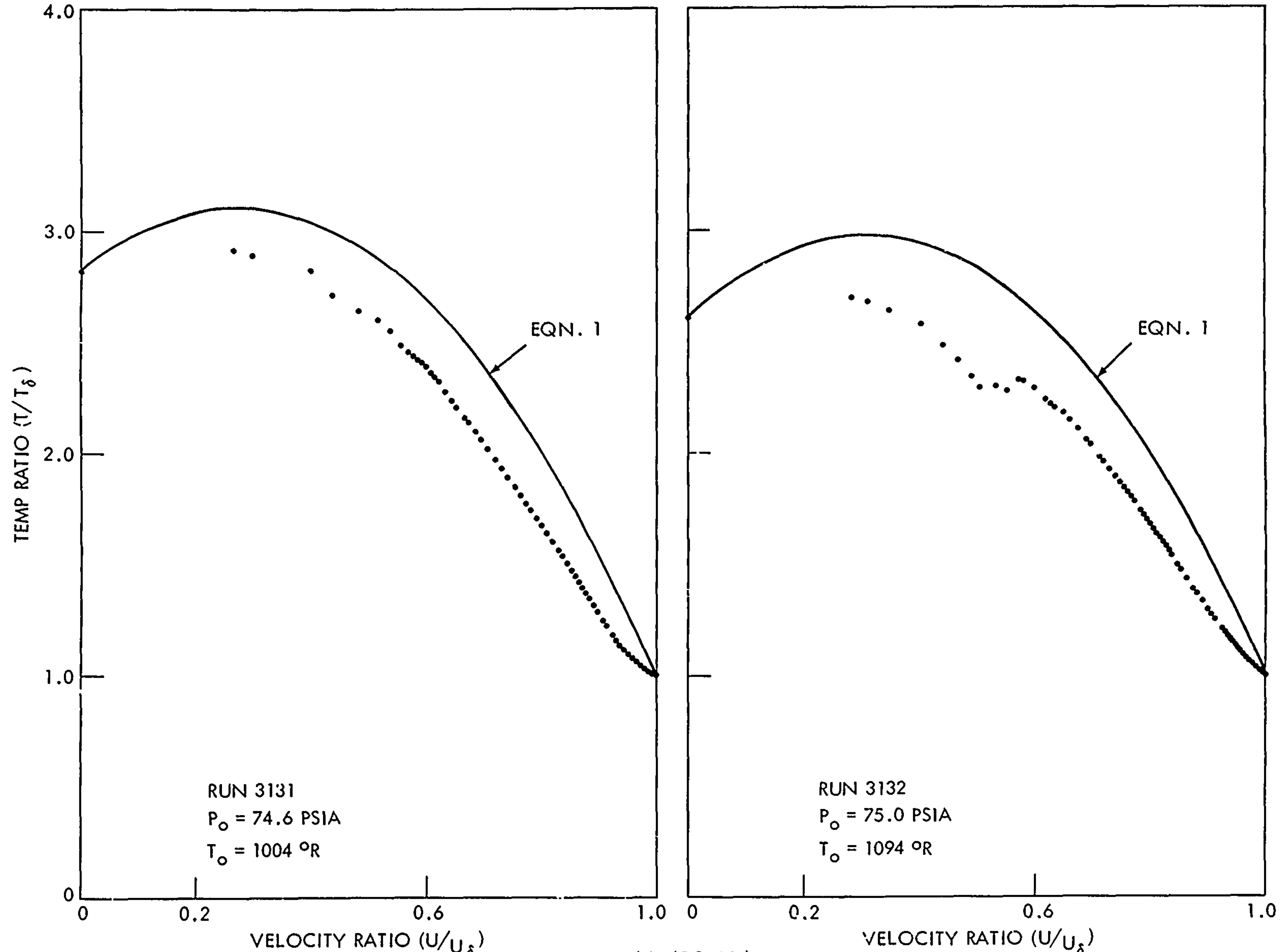

4.0
3.0
2.0
1.0
0
TEMP RATIO (T/T_δ)
EQN. 1
RUN 3131
P_o = 74.6 PSIA
T_o = 1004 °R
0
0.2
0.6
1.0
VELOCITY RATIO (U/U_δ)
EQN. 1
RUN 3132
P_o = 75.0 PSIA
T_o = 1094 °R
0
0.2
0.6
1.0
VELOCITY RATIO (U/U_δ)

FIG. 7c (3) (CONT.)

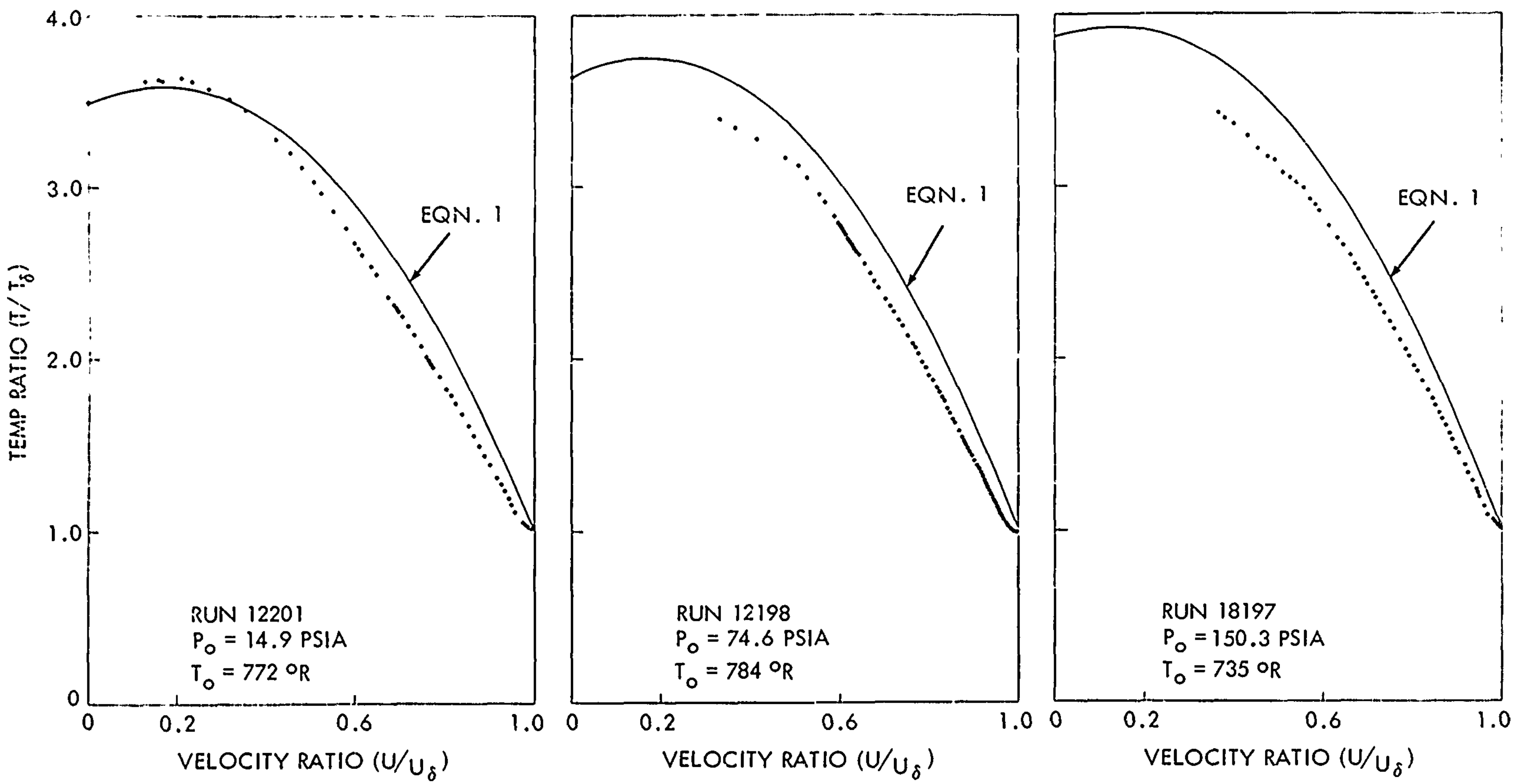


FIG. 7d STATIC TEMPERATURE - VELOCITY DISTRIBUTION AT THE 94 INCH STATION

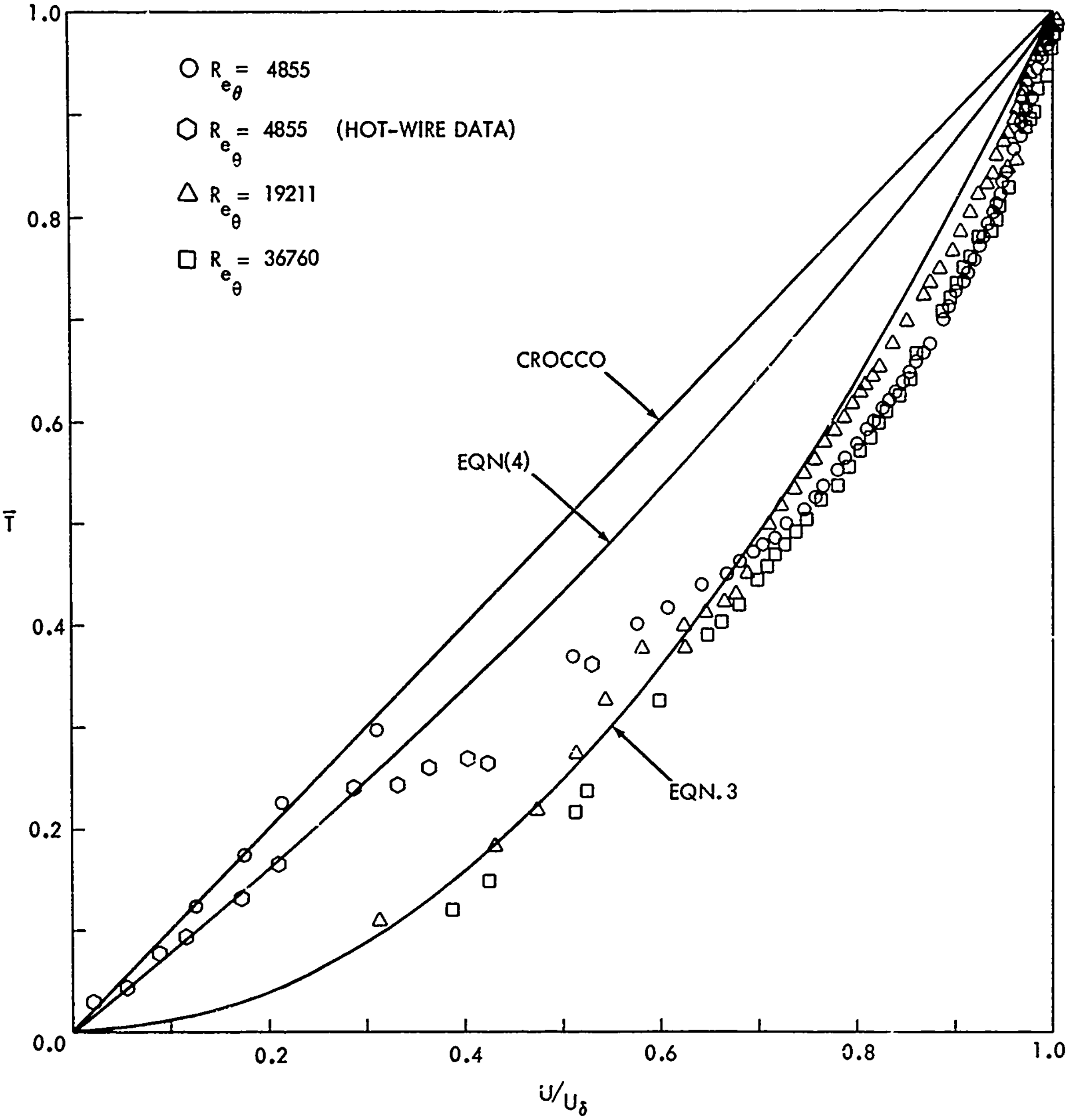


FIG. 8a TOTAL TEMPERATURE - VELOCITY DISTRIBUTION, 48 INCH STATION, Tw/Taw = .73

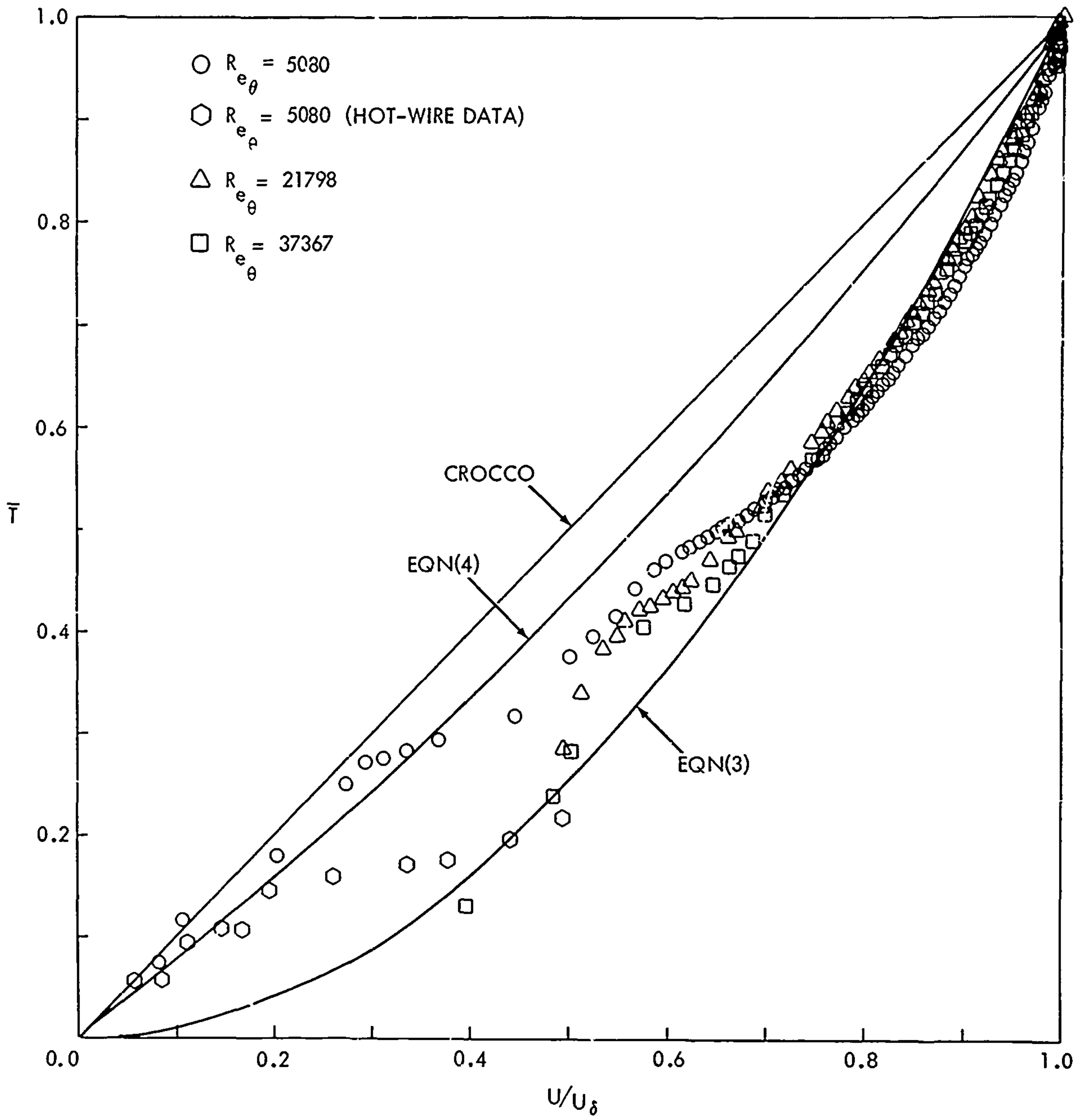


FIG. 8b TOTAL TEMPERATURE - VELOCITY DISTRIBUTION, 60 INCH STATION, Tw/Taw = .73

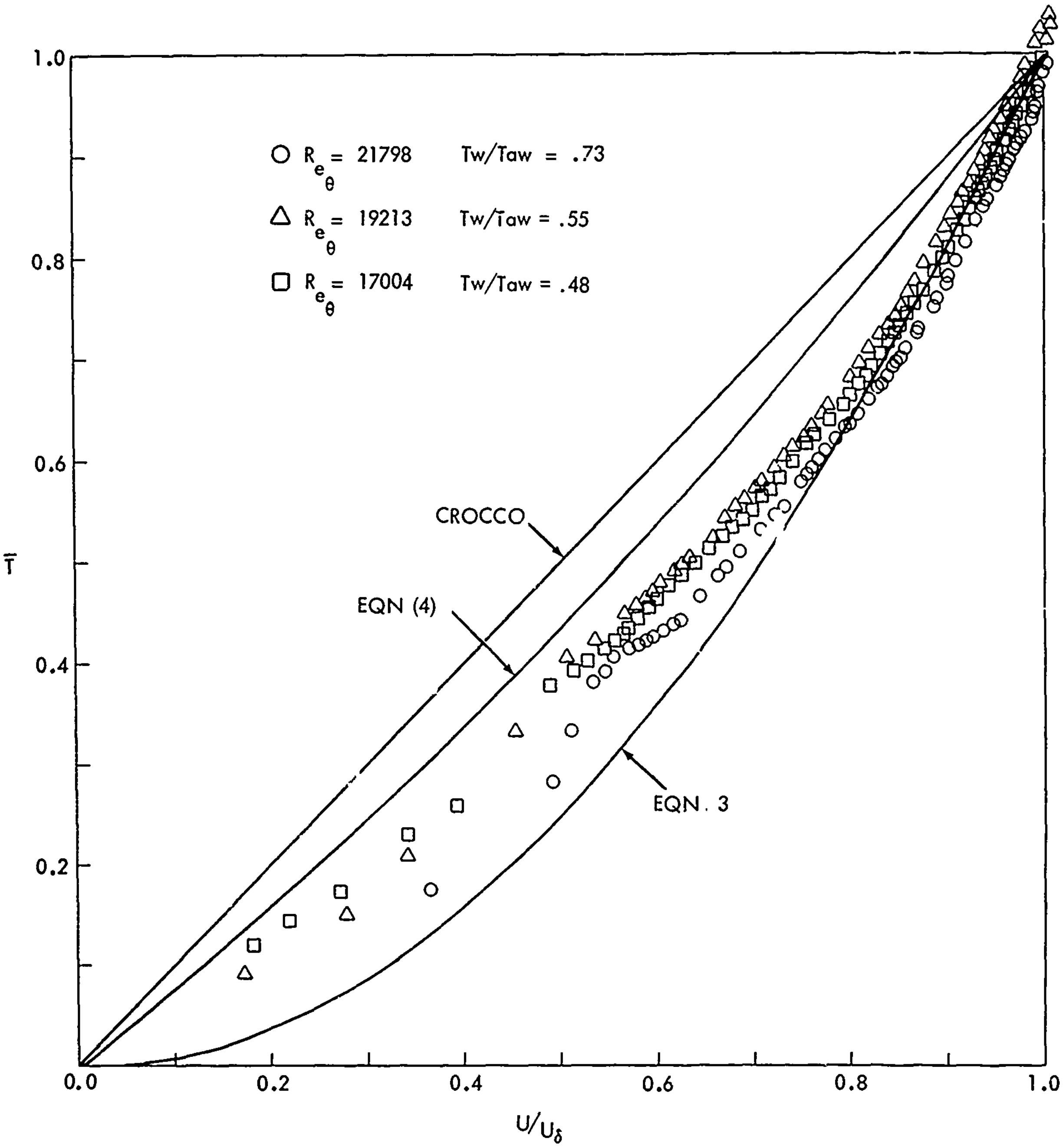


FIG. 8c TOTAL TEMPERATURE - VELOCITY DISTRIBUTION, 60 INCH STATION, P_o =5 atm.

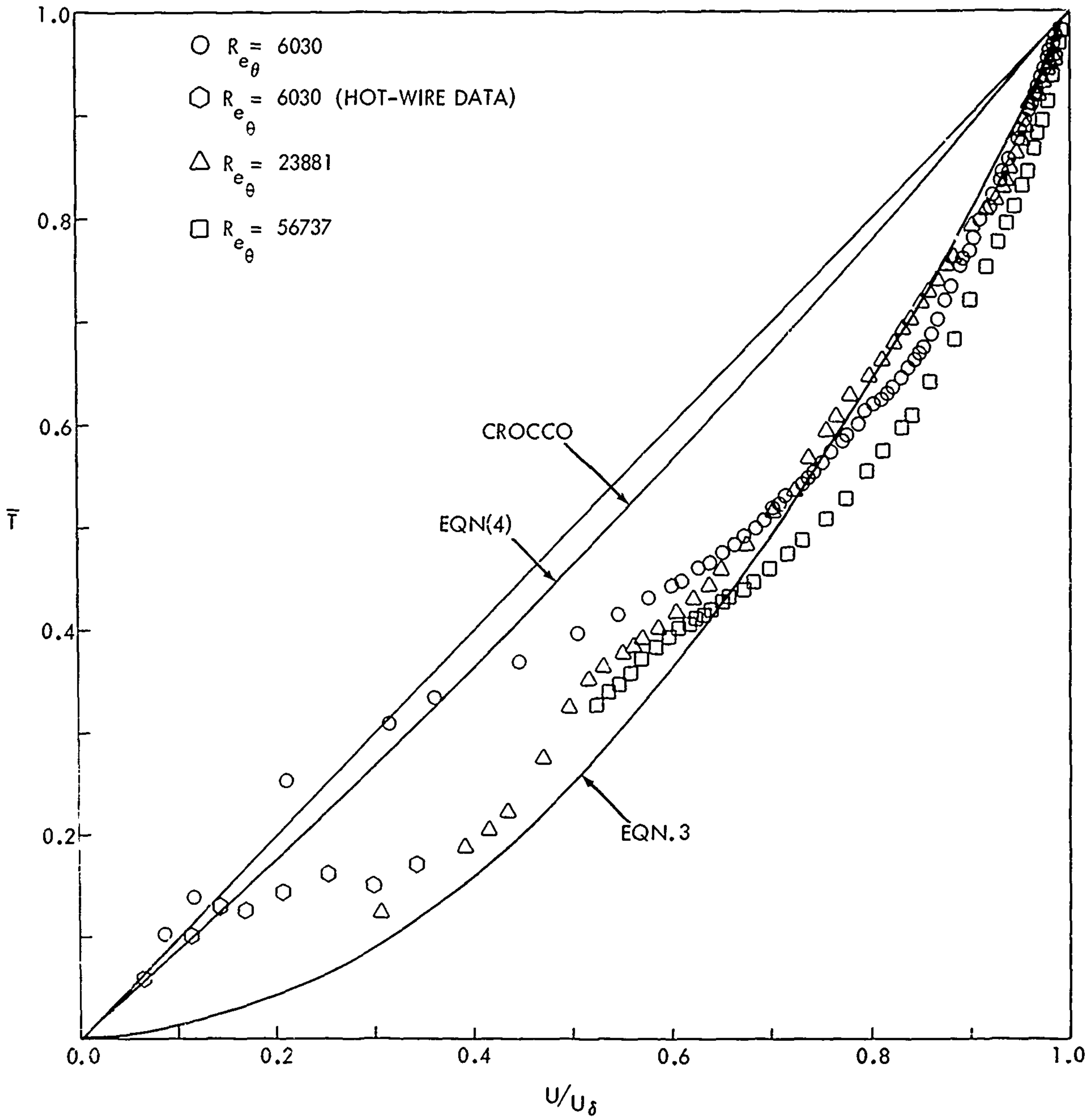


FIG. 8d TOTAL TEMPERATURE - VELOCITY DISTRIBUTION, 72 INCH STATION, Tw/Taw = .73

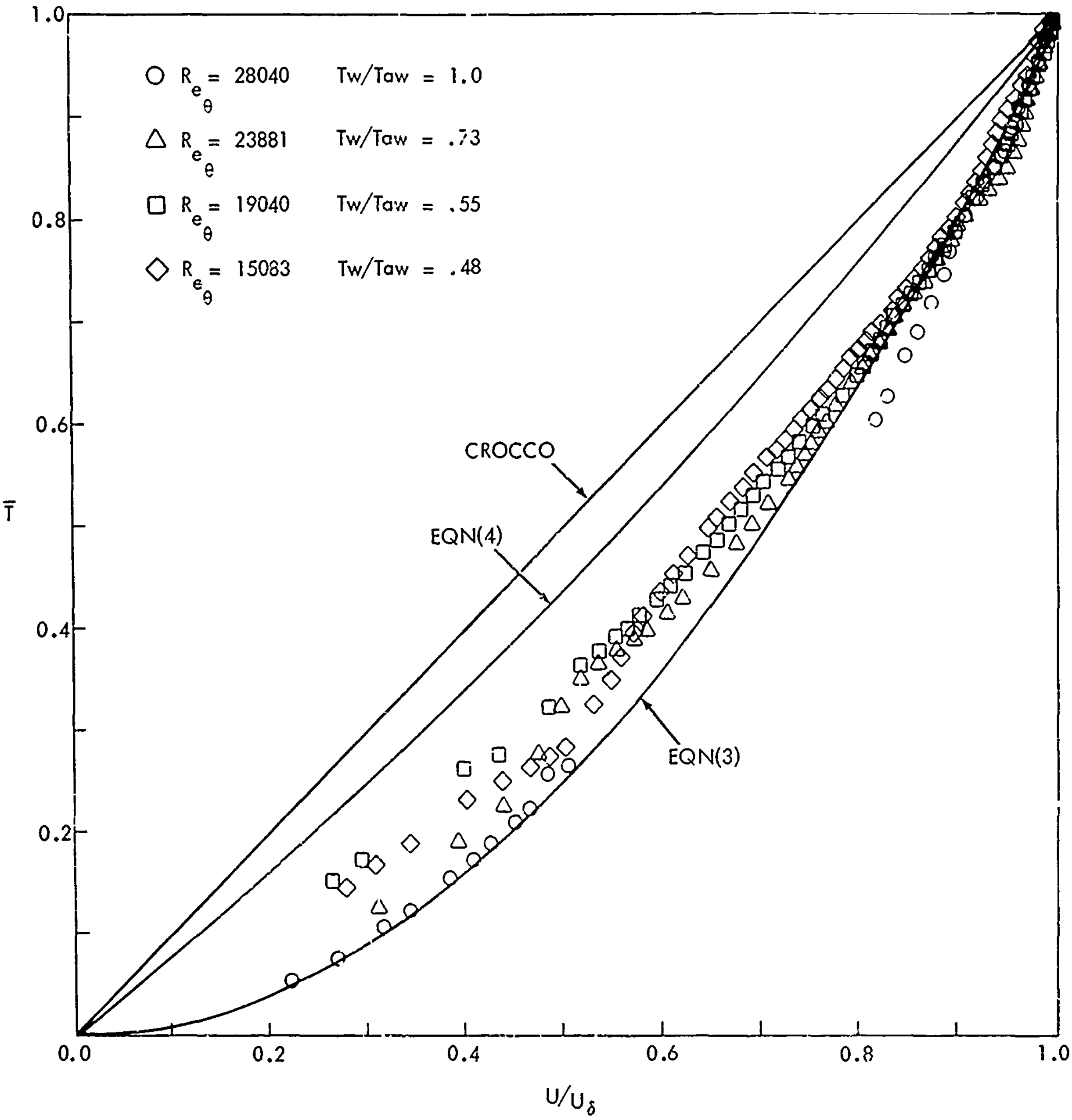


FIG. 8e TOTAL TEMPERATURE - VELOCITY DISTRIBUTION, 72 INCH STATION, P_o = 5atm

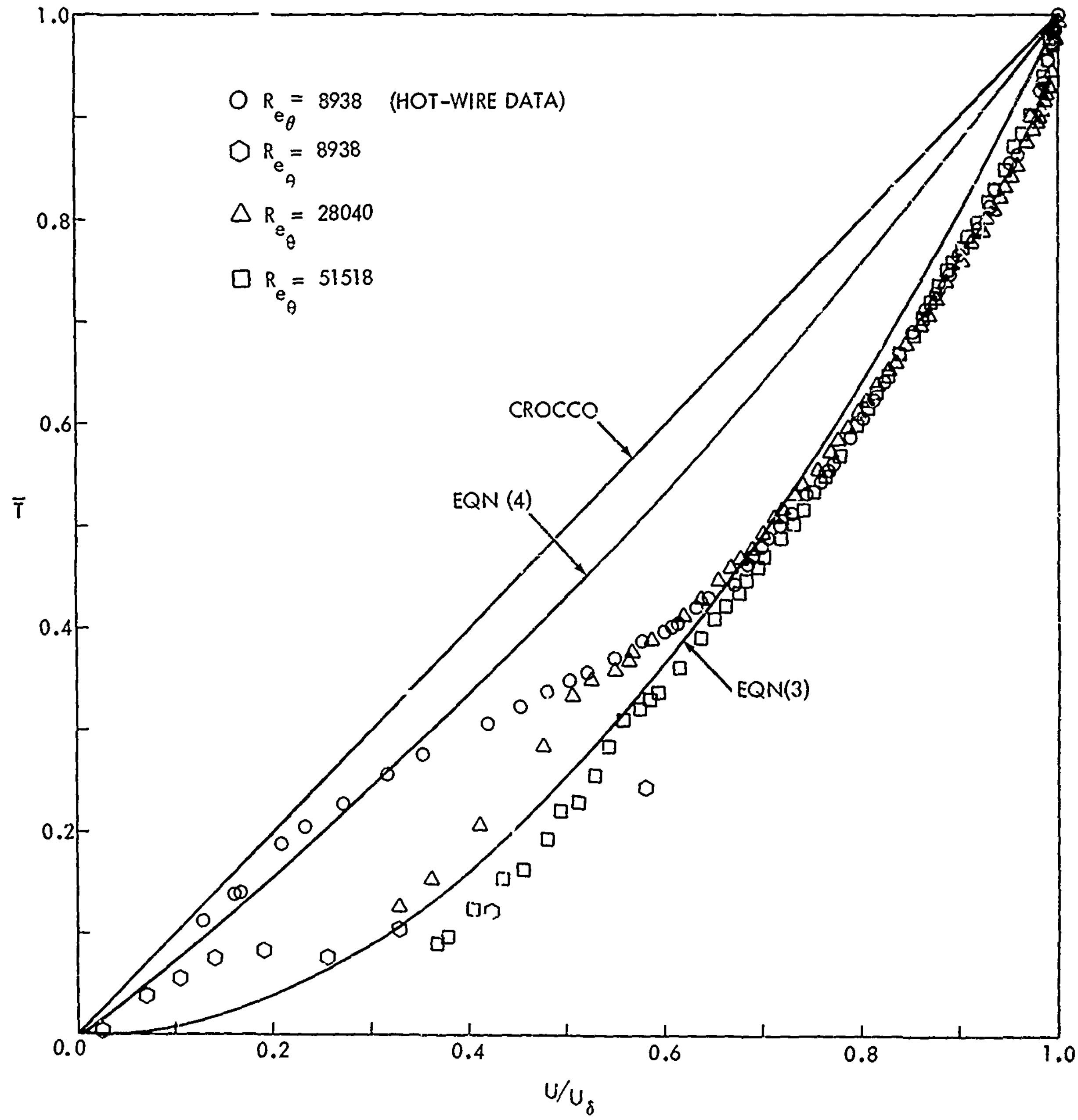


FIG. 8f TOTAL TEMPERATURE - VELOCITY DISTRIBUTION, 94 INCH STATION, T_w/T_{aw} = .73

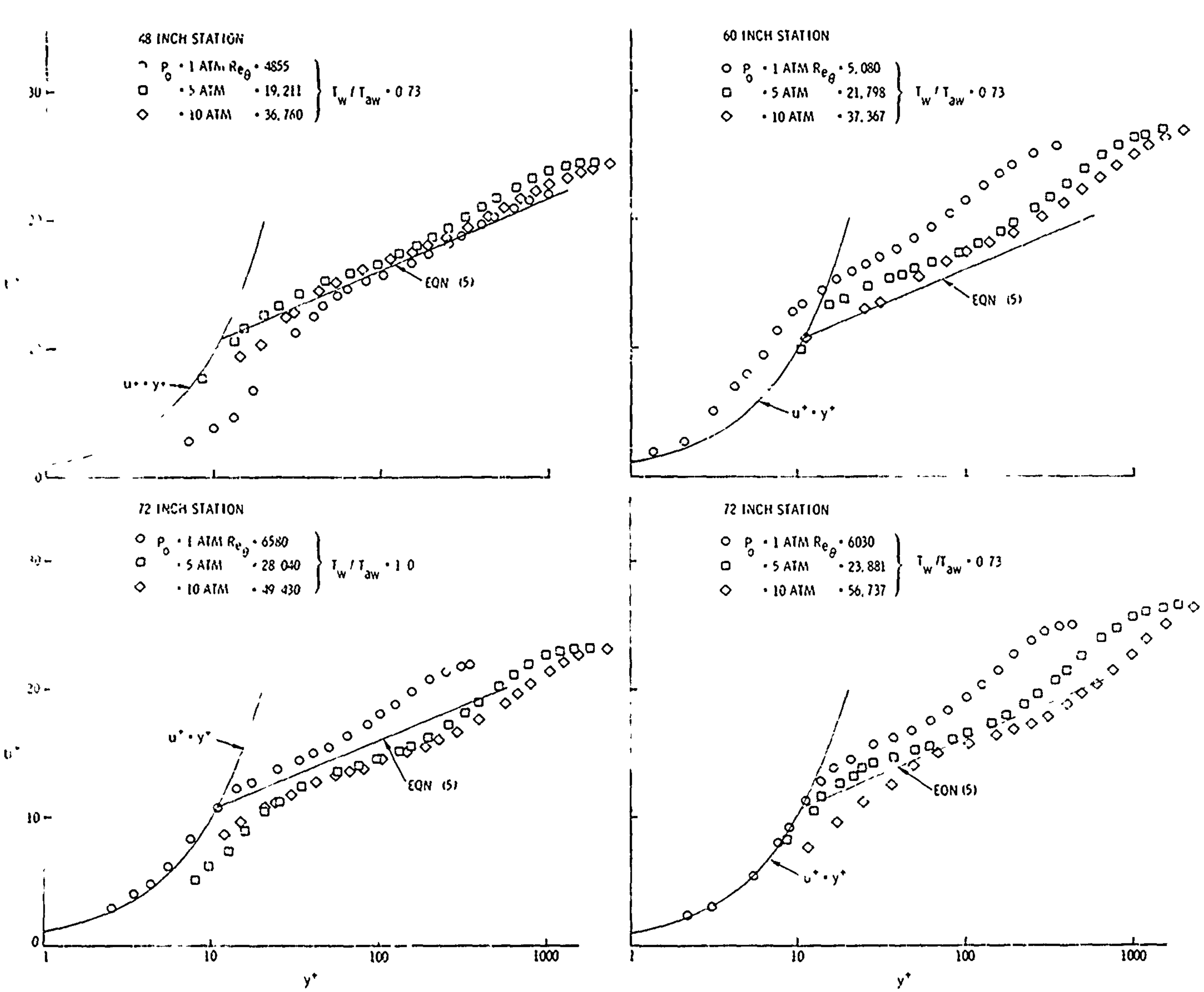


FIG 9a CORRELATION OF EXPERIMENTAL RESULTS IN TERMS OF LAW OF THE WALL

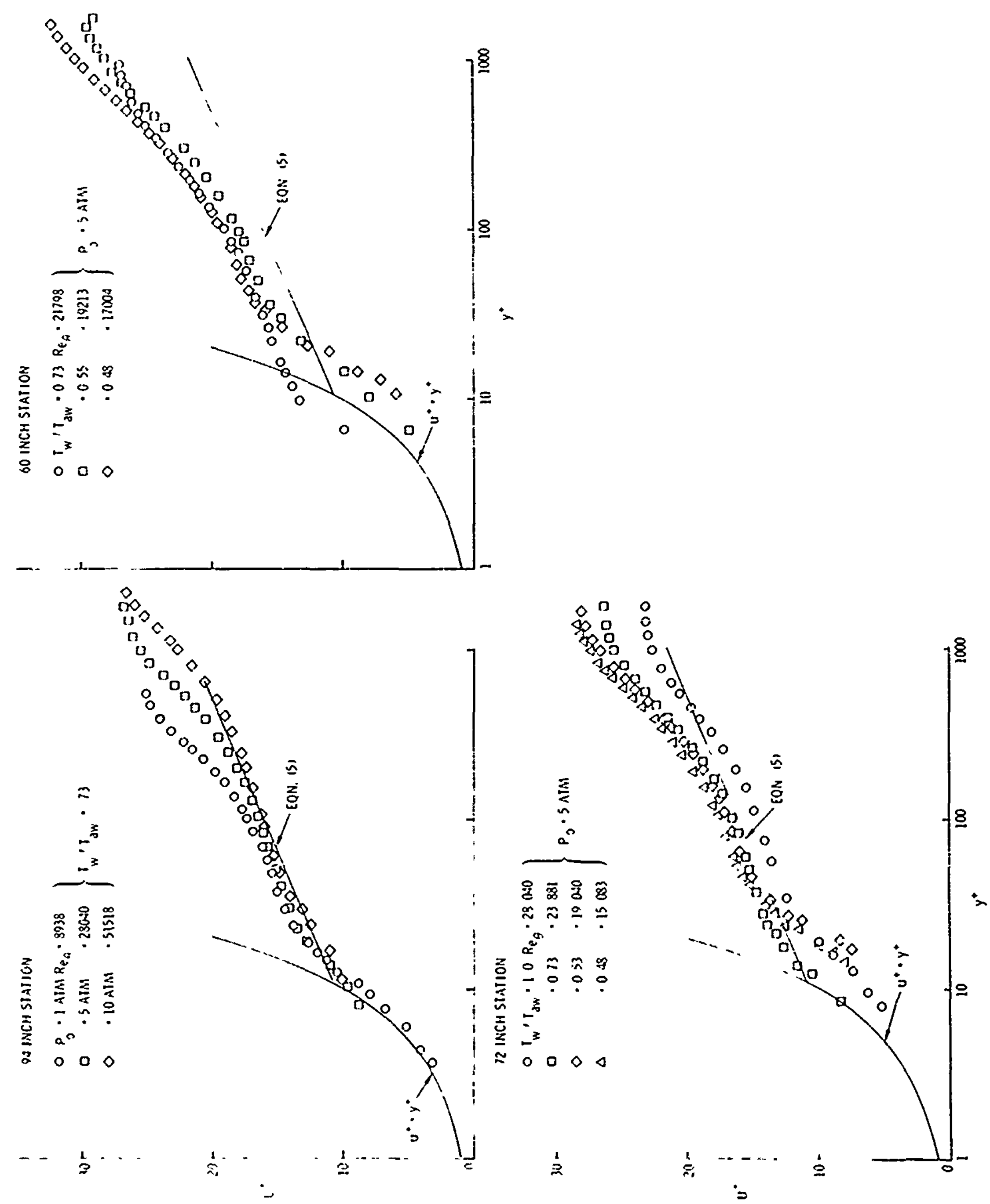

60 INCH STATION
EQN (5)
94 INCH STATION
EQN. (5)
72 INCH STATION
EQN (5)
y+
u+

FIG 9b (CONT.)

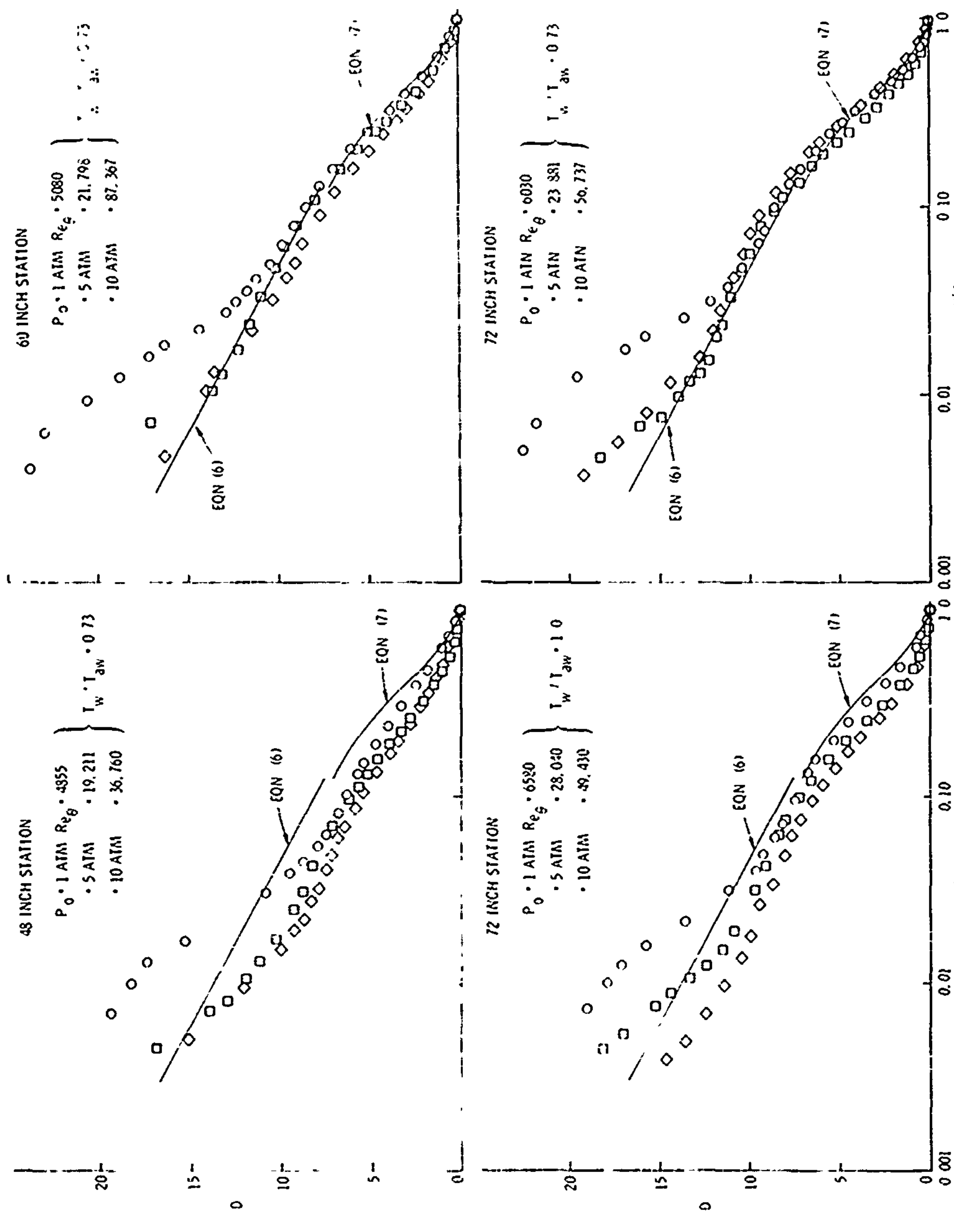


FIG 10a CORRELATION OF EXPERIMENTAL RESULTS IN TERMS OF VELOCITY DEFECT LAW

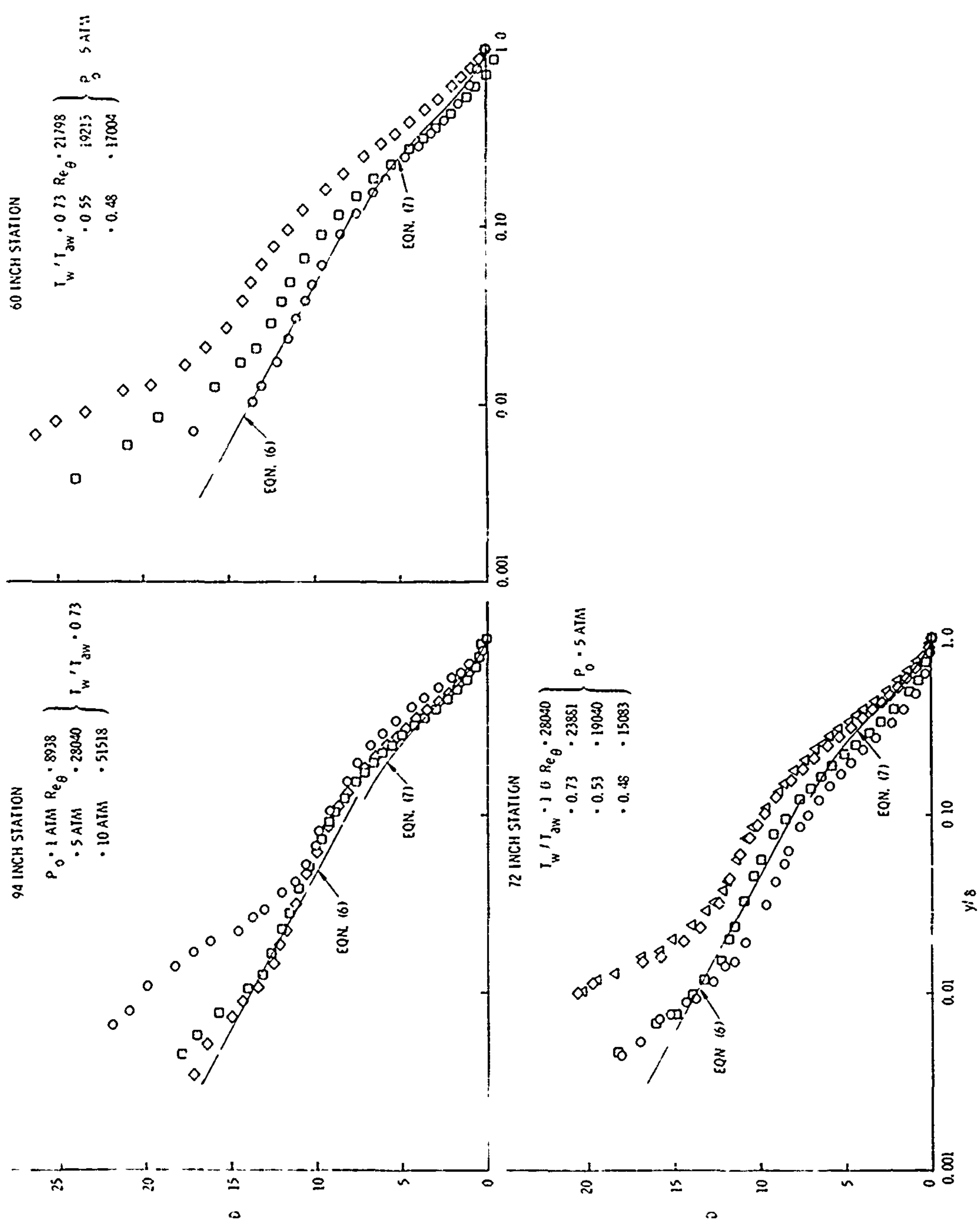

60 INCH STATION
T_w/T_aw = 0.73 Re_θ = 21798
= 0.55 19215
= 0.48 17004
P_o 5 ATM
94 INCH STATION
P_o = 1 ATM Re_θ = 8938
= 5 ATM = 28040
= 10 ATM = 51518
T_w/T_aw = 0.73
72 INCH STATION
T_w/T_aw = 1.0 Re_θ = 28040
= 0.73 = 23881
= 0.53 = 19040
= 0.48 = 15083
P_o = 5 ATM
EQN. (6)
EQN. (7)
y/δ

FIG 10b (CONT.)

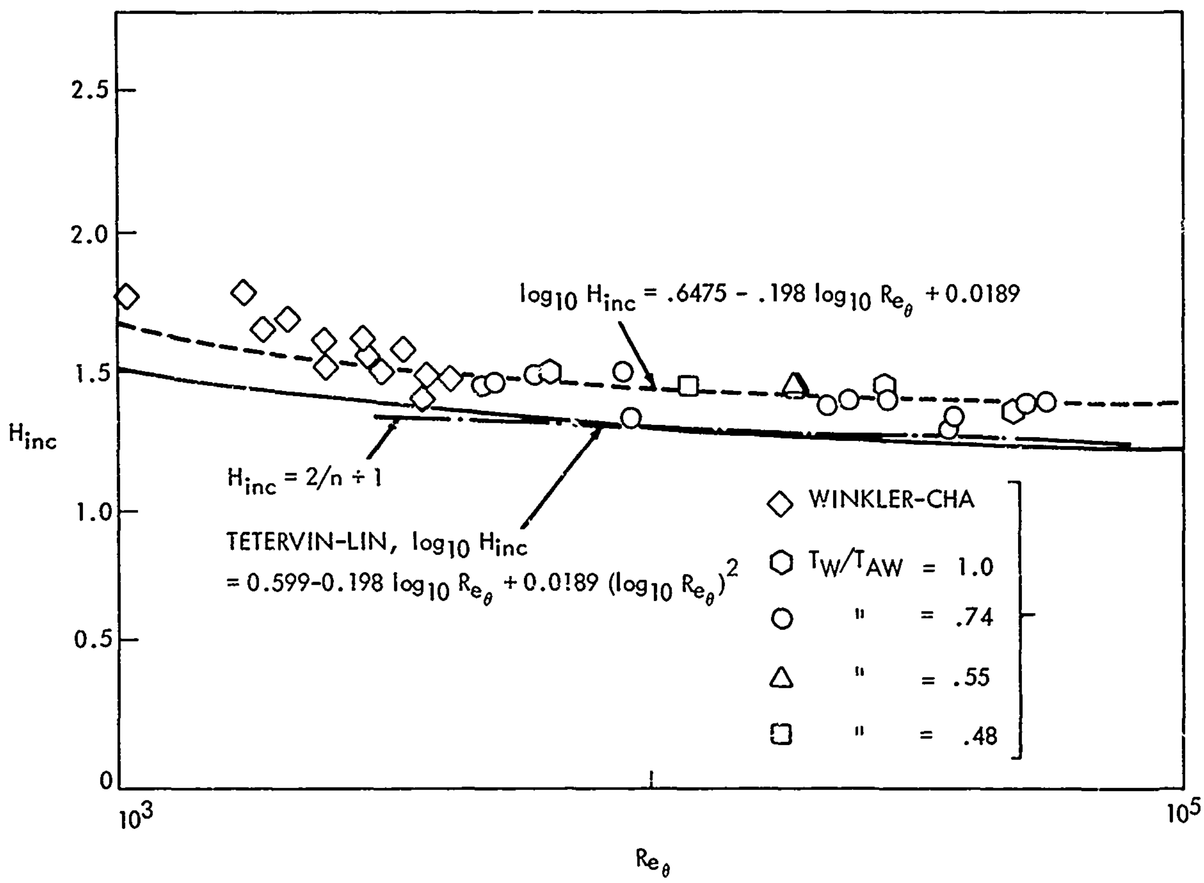


FIG. 11 VARIATION OF INCOMPRESSIBLE FORM FACTOR WITH MOMENTUM THICKNESS REYNOLDS NUMBER

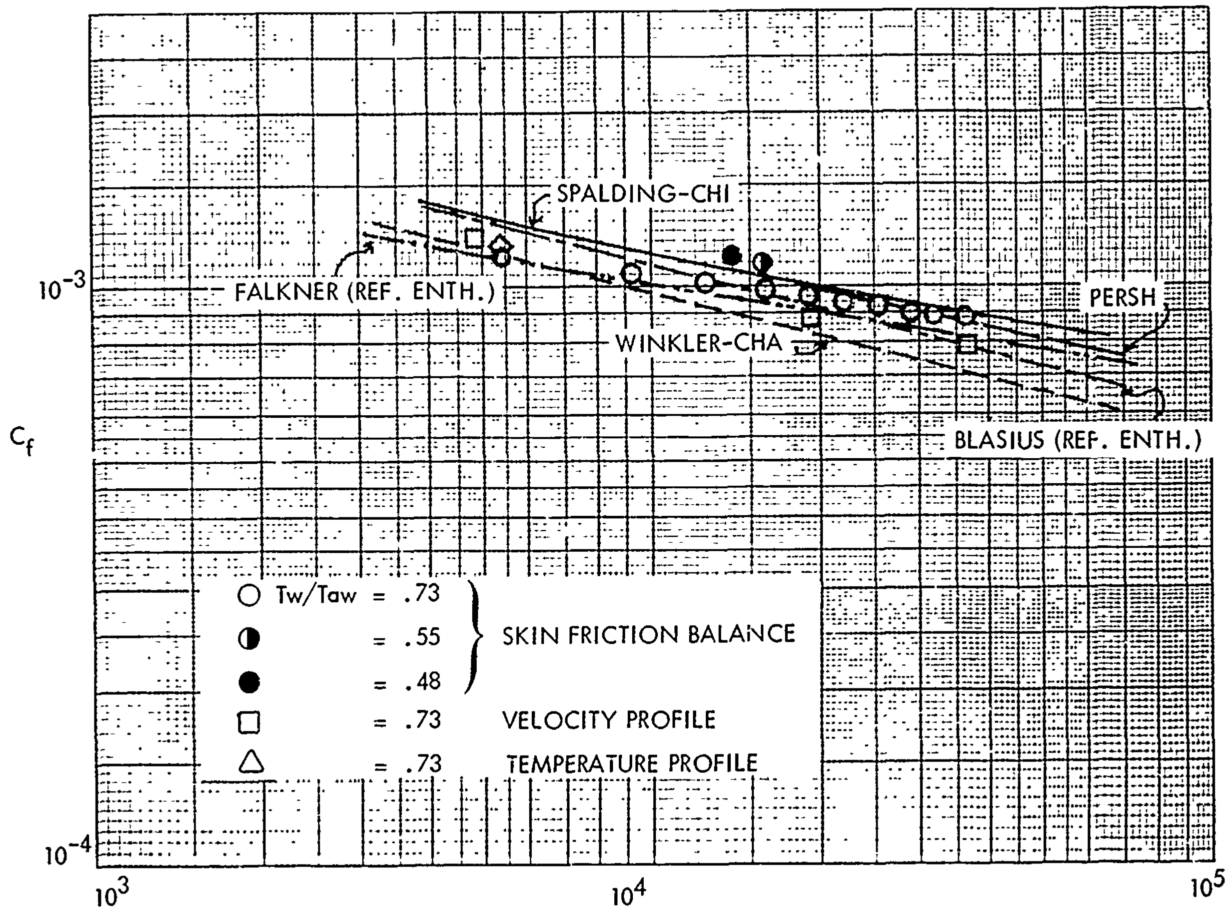


FIG. 12a FRICTION COEFFICIENT CORRELATION, 48" STATION

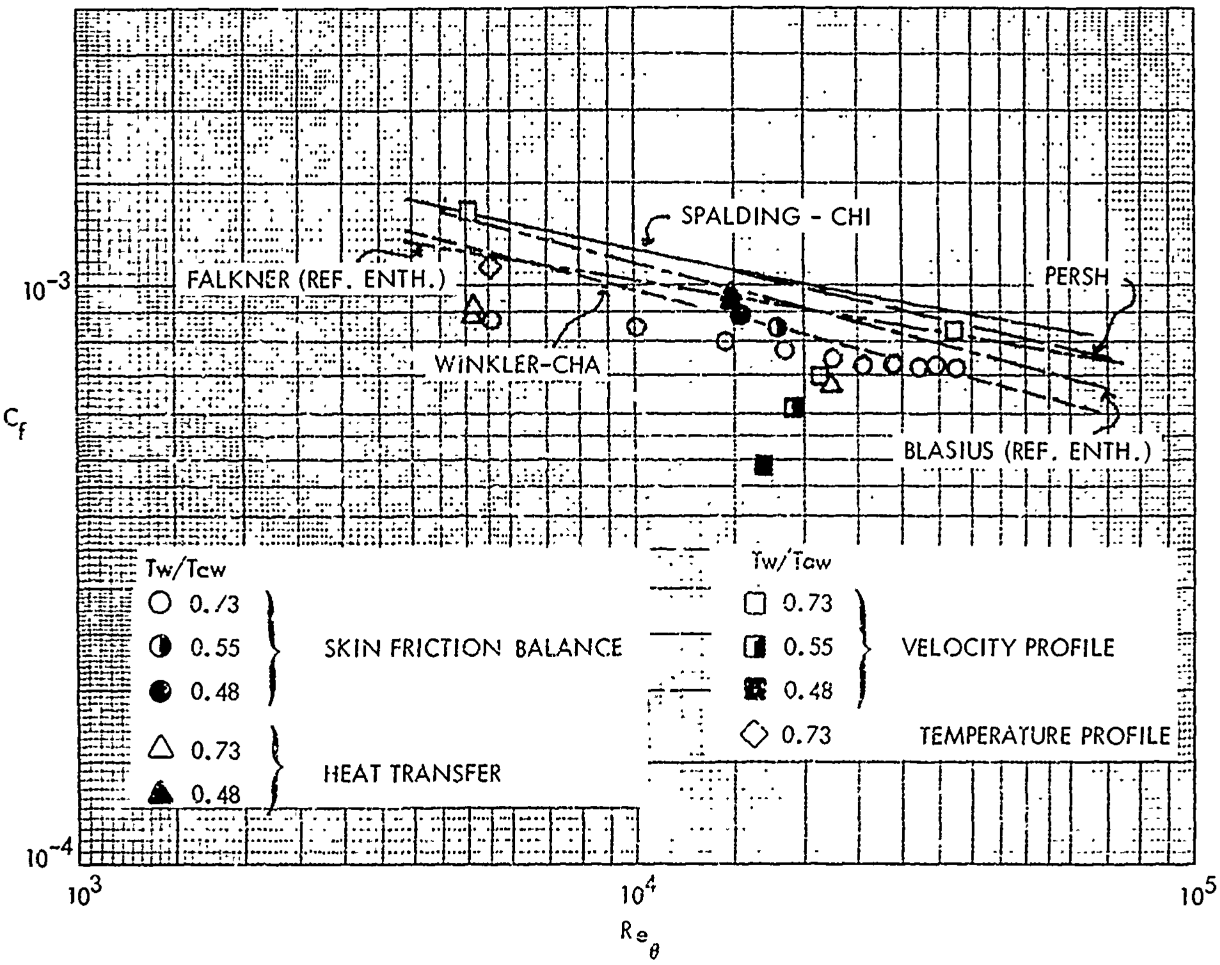


FIG. 12b FRICTION COEFFICIENT CORRELATION,60 INCH STATION

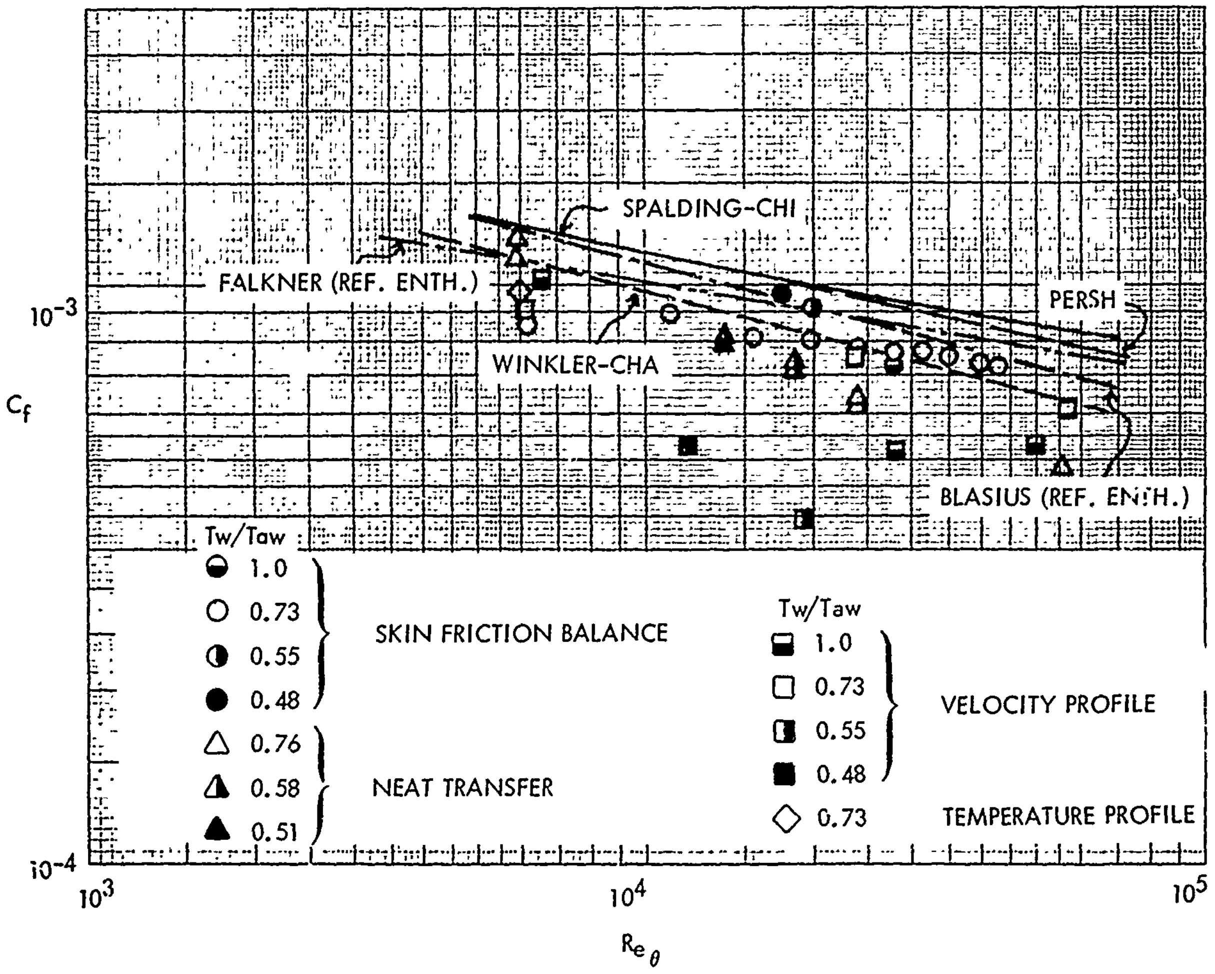


FIG. 12c FRICTION COEFFICIENT CORRELATION, 72 INCH STATION

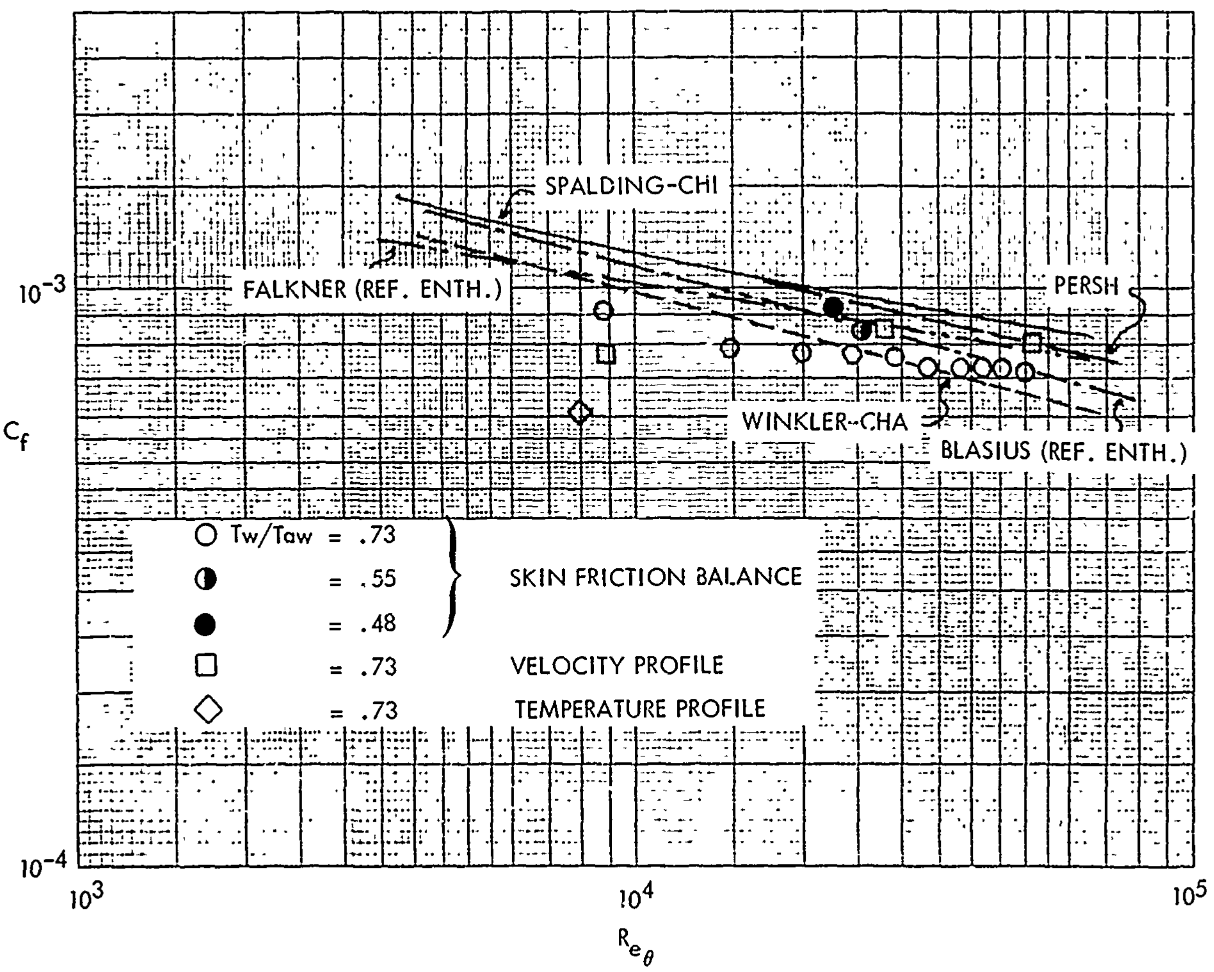


FIG. 12d FRICTION COEFFICIENT CORRELATION, 94" STATION

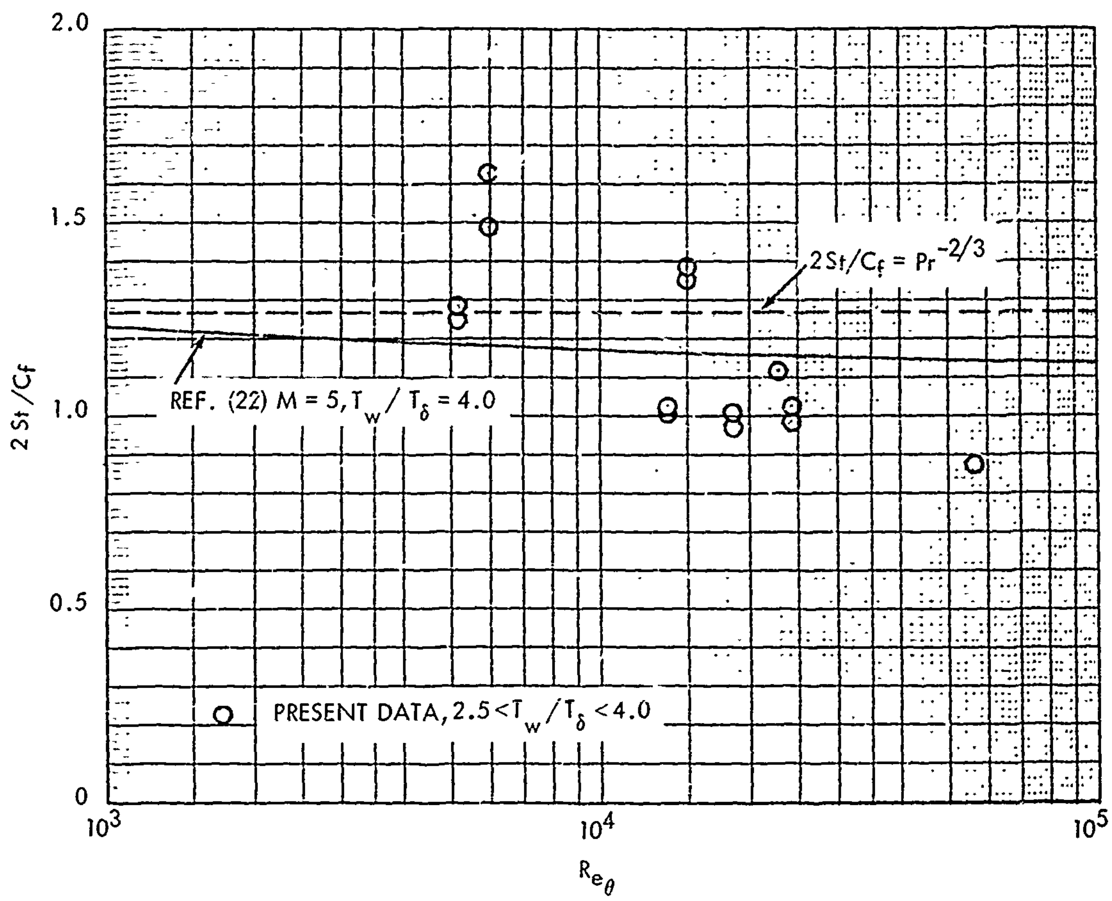


FIG. 13 REYNOLDS ANALOGY FACTOR AS A FUNCTION OF MOMENTUM THICKNESS REYNOLDS NUMBER

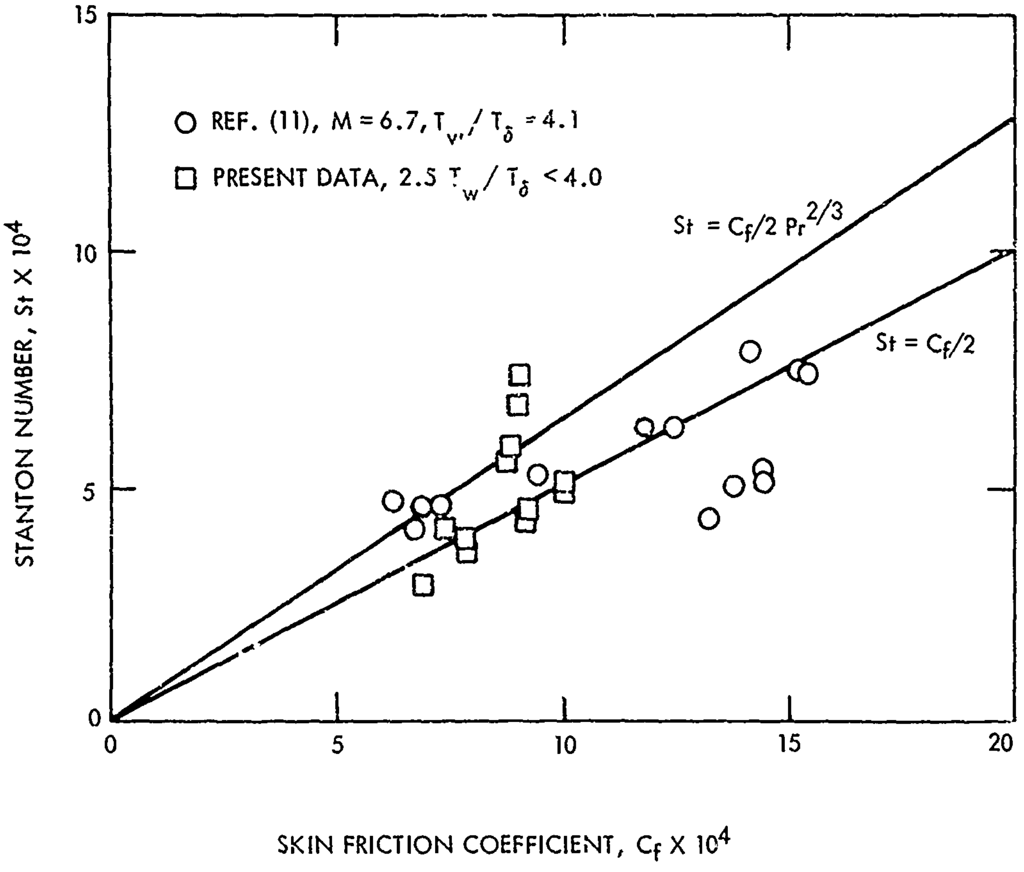


FIG. 14 EXPERIMENTAL REYNOLDS ANALOGY CORRELATION

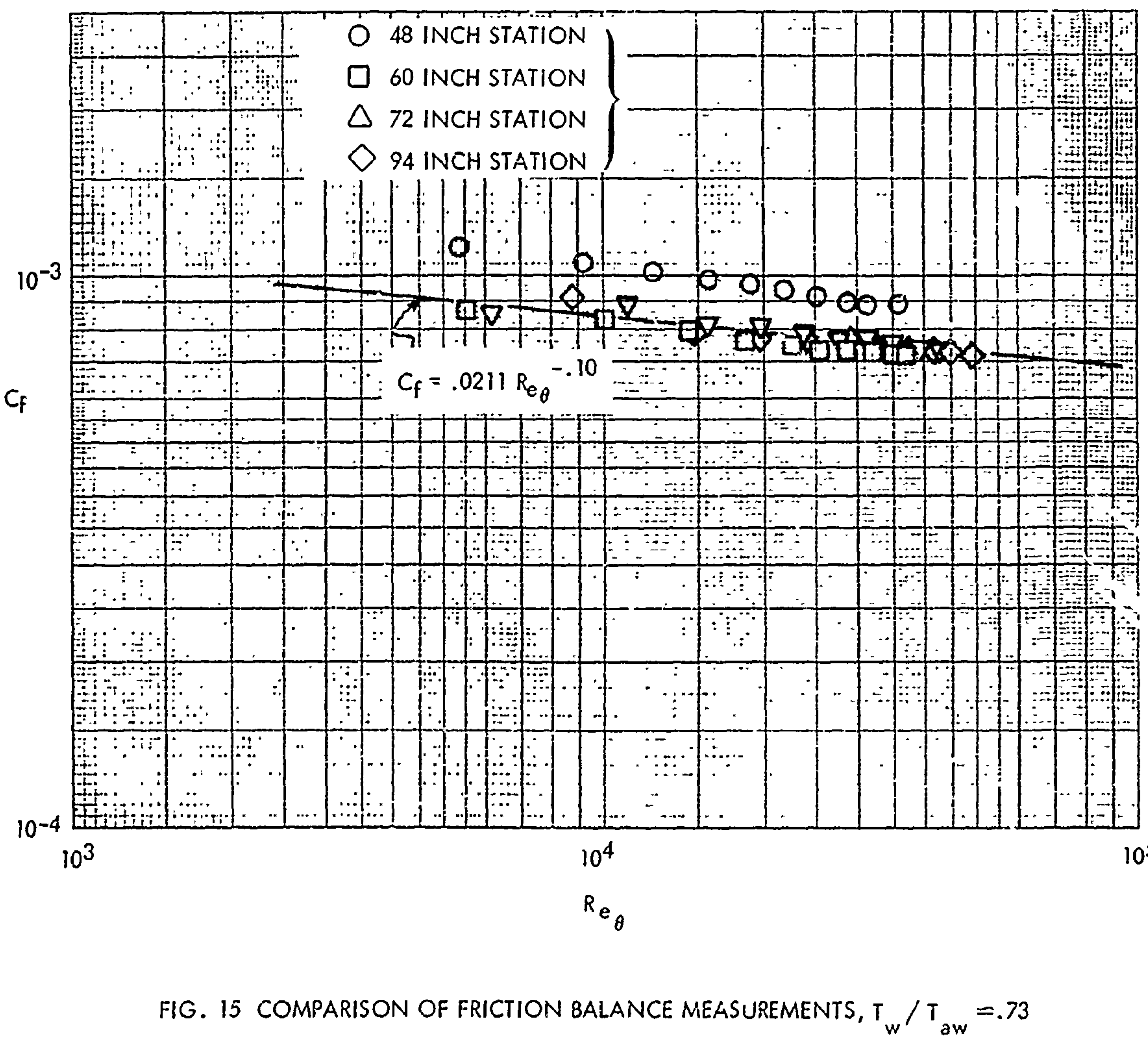


FIG. 15 COMPARISON OF FRICTION BALANCE MEASUREMENTS, $T_w / T_{aw} = .73$

$d/dy\ (\mu\, du/dy) = 0$

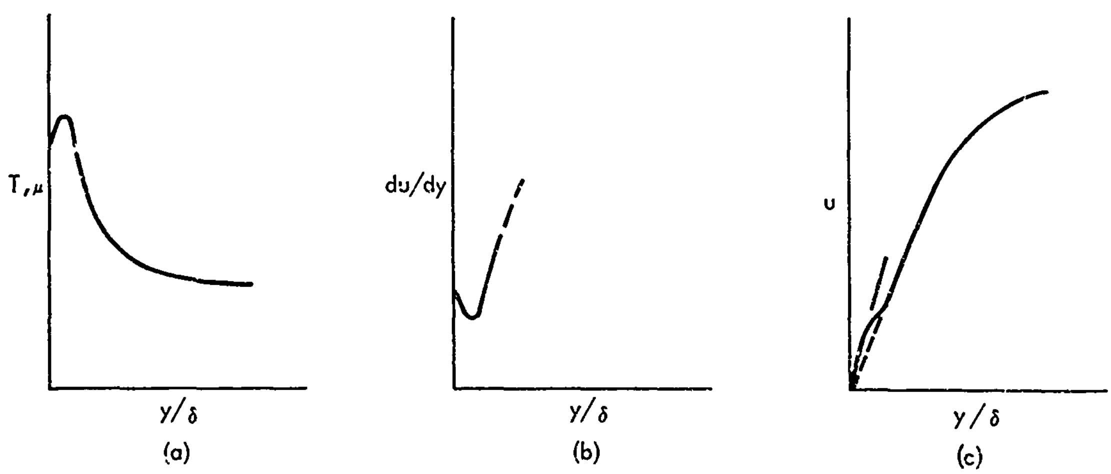


FIG. 16 ILLUSTRATION OF PROBABLE TEMPERATURE DISTORTION OF VELOCITY PROFILE

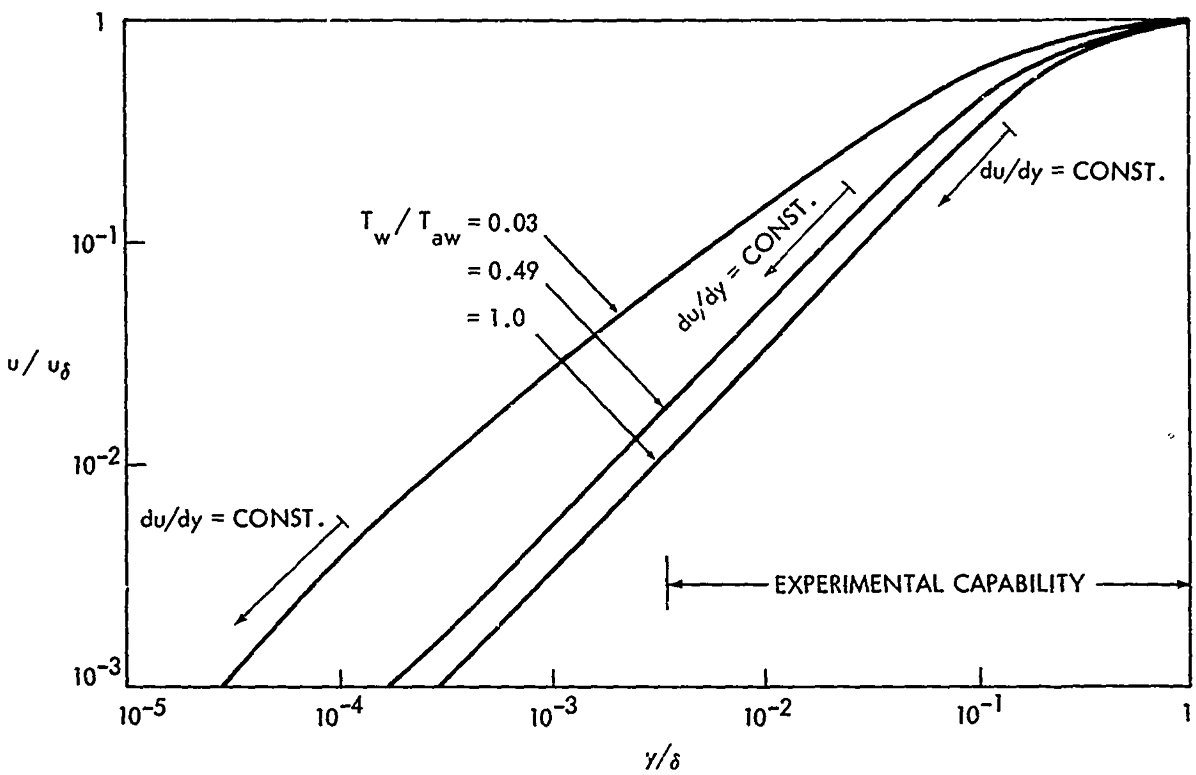


FIG. 17 LINEAR PORTION OF VELOCITY PROFILE FOR THREE VALUES OF T_W/T_{AW} AS COMPUTED BY THE METHOD OF TETERVIN FOR M = 10

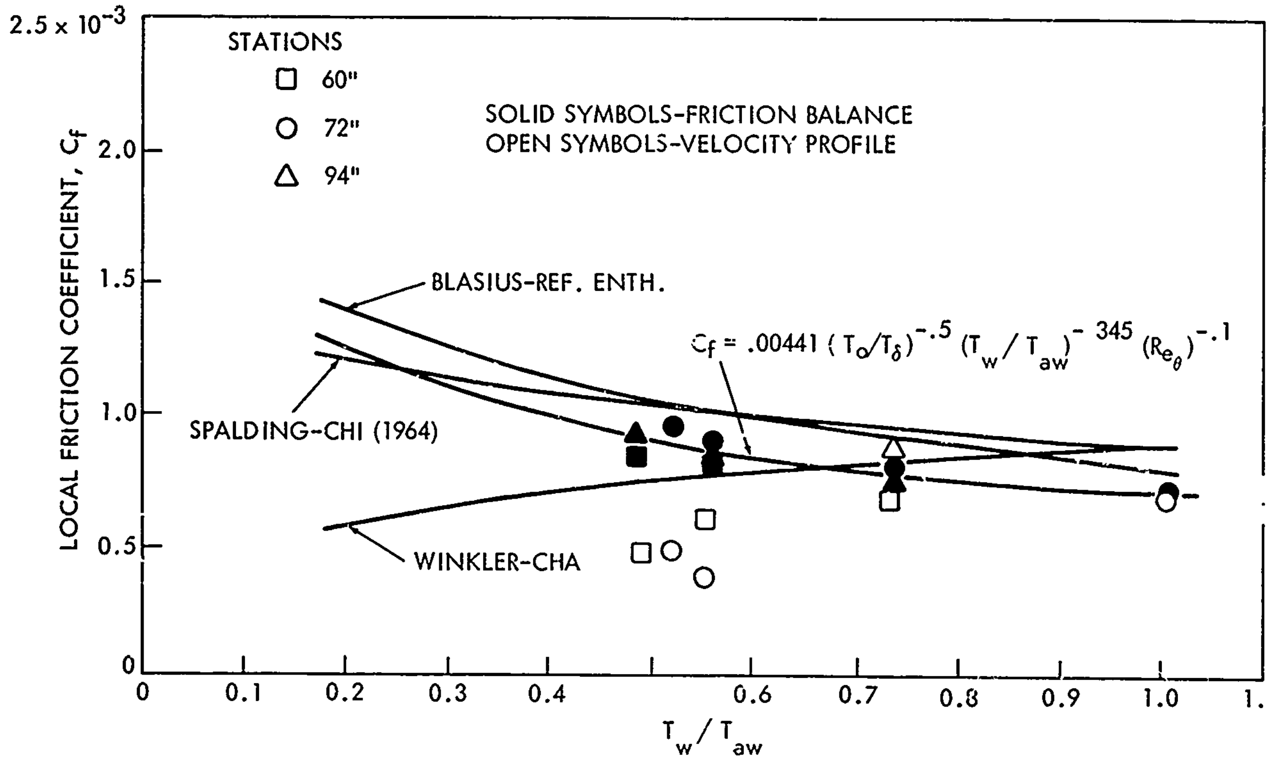


FIG. 18 EFFECT OF WALL TEMPERATURE ON LOCAL FRICTION COEFFICIENT, $R_{e_\theta} = 20,000$, $M_\delta = 4.7$

TABLE 1(a) BOUNDARY LAYER PROFILE MEASUREMENTS

Run 12196	X = 45.25 inches	Re_θ = 4855
P_o = 14.7 psia	T_∞ = 145.0 °R	δ^* = 0.616 inch
T_o = 783.9 °R	U_∞ = 2770 ft/sec	θ = 0.104 inch
T_w = 517 °R	M_∞ = 4.69	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.564	0.	0.281
2	0.014	0.302	3.726	0.124	0.268
3	0.020	0.424	3.752	0.175	0.267
4	0.026	0.513	3.781	0.213	0.264
5	0.034	0.751	3.696	0.308	0.271
6	0.061	1.362	3.103	0.511	0.322
7	0.078	1.578	2.874	0.570	0.348
8	0.089	1.713	2.733	0.604	0.366
9	0.100	1.883	2.562	0.642	0.390
10	0.125	1.986	2.459	0.664	0.407
11	0.147	2.064	2.385	0.679	0.419
12	0.163	2.133	2.323	0.693	0.431
13	0.180	2.183	2.277	0.702	0.439
14	0.205	2.247	2.220	0.713	0.450
15	0.229	2.318	2.160	0.726	0.463
16	0.235	2.352	2.130	0.732	0.469
17	0.265	2.410	2.085	0.742	0.480
18	0.301	2.489	2.024	0.755	0.494
19	0.326	2.546	1.979	0.764	0.505
20	0.353	2.626	1.924	0.776	0.520
21	0.381	2.688	1.883	0.786	0.531
22	0.414	2.772	1.824	0.798	0.548
23	0.441	2.845	1.775	0.808	0.563
24	0.475	2.915	1.730	0.817	0.578
25	0.505	2.980	1.690	0.825	0.592
26	0.527	3.035	1.655	0.832	0.604
27	0.560	3.087	1.624	0.838	0.616
28	0.585	3.162	1.579	0.847	0.633
29	0.612	3.218	1.547	0.853	0.646
30	0.640	3.272	1.518	0.859	0.659
31	0.673	3.332	1.487	0.866	0.673
32	0.703	3.406	1.448	0.874	0.691
33	0.736	3.478	1.412	0.881	0.708
34	0.778	3.545	1.381	0.888	[illegible]
35	0.813	3.609	1.352	0.894	0.740
36	0.855	3.673	1.325	0.901	0.755
37	0.879	3.731	1.300	0.907	0.769
38	0.907	3.780	1.279	0.911	0.782
39	0.937	3.822	1.262	0.915	0.792
40	0.976	3.881	1.238	0.920	0.808
41	1.003	3.933	1.217	0.925	0.822
42	1.039	3.979	1.199	0.929	0.834
43	1.061	4.014	1.186	0.932	0.843
44	1.097	4.049	1.175	0.935	0.851
45	1.114	4.082	1.163	0.938	0.860
46	1.147	4.130	1.147	0.942	0.872
47	1.177	4.162	1.137	0.946	0.880
48	1.205	4.194	1.127	0.949	0.887
49	1.232	4.221	1.119	0.951	0.894
50	1.276	4.265	1.105	0.956	0.905
51	1.320	4.303	1.096	0.960	0.913
52	1.356	4.340	1.086	0.964	0.921
53	1.389	4.371	1.078	0.967	0.928
54	1.439	4.409	1.066	0.970	0.938
55	1.480	4.439	1.056	0.972	0.947
56	1.527	4.469	1.048	0.975	0.955
57	1.574	4.501	1.039	0.978	0.963
58	1.626	4.534	1.033	0.982	0.968
59	1.673	4.561	1.028	0.985	0.973
60	1.714	4.580	1.025	0.988	0.976
61	1.778	4.615	1.019	0.993	0.981
62	1.811	4.628	1.016	0.994	0.984
63	1.846	4.642	1.012	0.995	0.988
64	1.885	4.661	1.005	0.996	0.995
65	1.924	4.669	1.003	0.996	0.997
66	1.959	4.685	1.000	0.998	1.000
67	1.990	4.692	1.000	1.000	1.000

TABLE 1(b)(CONT.)

Run 12195	X = 45.25 inches	Re_θ = 19211
P_o = 75.0 psia	T_∞ = 149.4 °R	δ^* = 0.465 inch
T_o = 783.2 °R	U_∞ = 2759 ft/sec	θ = 0.0771 inch
T_w = 514 °R	M_∞ = 4.60	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.440	0.	0.291
2	0.009	0.806	3.220	0.314	0.311
3	0.014	1.150	2.981	0.431	0.335
4	0.016	1.284	2.882	0.473	0.347
5	0.021	1.412	2.815	0.514	0.355
6	0.026	1.503	2.778	0.544	0.360
7	0.034	1.635	2.688	0.582	0.372
8	0.044	1.762	2.562	0.612	0.390
9	0.046	1.783	2.542	0.617	0.393
10	0.049	1.809	2.515	0.623	0.398
11	0.061	1.906	2.422	0.644	0.413
12	0.069	1.931	2.399	0.649	0.417
13	0.084	1.998	2.338	0.663	0.428
14	0.101	2.062	2.280	0.676	0.439
15	0.119	2.130	2.228	0.691	0.449
16	0.136	2.218	2.188	0.712	0.457
17	0.154	2.265	2.156	0.722	0.464
18	0.174	2.337	2.103	0.736	0.475
19	0.191	2.402	2.057	0.748	0.486
20	0.204	2.446	2.026	0.756	0.494
21	0.224	2.515	1.979	0.768	0.505
22	0.241	2.575	1.937	0.778	0.516
23	0.259	2.639	1.893	0.788	0.528
24	0.276	2.701	1.851	0.798	0.540
25	0.294	2.750	1.813	0.806	0.552
26	0.309	2.797	1.789	0.812	0.559
27	0.319	2.835	1.764	0.817	0.567
28	0.336	2.888	1.730	0.825	0.578
29	0.346	2.921	1.710	0.829	0.585
30	0.376	2.989	1.672	0.839	0.598
31	0.409	3.095	1.612	0.853	0.621
32	0.436	3.180	1.564	0.863	0.639
33	0.461	3.235	1.534	0.870	0.652
34	0.486	3.297	1.502	0.877	0.666
35	0.513	3.365	1.467	0.885	0.682
36	0.558	3.476	1.411	0.897	0.709
37	0.601	3.571	1.368	0.907	0.731
38	0.643	3.659	1.329	0.916	0.752
39	0.668	3.710	1.308	0.921	0.765
40	0.696	3.761	1.286	0.926	0.777
41	0.721	3.811	1.265	0.931	0.790
42	0.738	3.843	1.252	0.934	0.799
43	0.763	3.889	1.233	0.938	0.811
44	0.783	3.916	1.223	0.941	0.817
45	0.806	3.956	1.209	0.944	0.827
46	0.833	3.997	1.192	0.948	0.839
47	0.858	4.033	1.180	0.951	0.847
48	0.886	4.074	1.165	0.955	0.858
49	0.911	4.106	1.154	0.958	0.867
50	0.946	4.146	1.139	0.961	0.878
51	0.985	4.192	1.124	0.965	0.890
52	1.028	4.237	1.110	0.969	0.901
53	1.065	4.276	1.097	0.973	0.911
54	1.120	4.323	1.082	0.976	0.924
55	1.175	4.364	1.069	0.980	0.935
56	1.245	4.413	1.055	0.984	0.948
57	1.305	4.453	1.041	0.986	0.961
58	1.360	4.480	1.031	0.988	0.970
59	1.470	4.522	1.016	0.990	0.984
60	1.517	4.540	1.012	0.992	0.988
61	1.560	4.551	1.012	0.994	0.988
62	1.610	4.564	1.009	0.995	0.992
63	1.657	4.574	1.005	0.996	0.995
64	1.705	4.579	1.003	0.996	0.997
65	1.817	4.592	0.998	0.996	1.002
66	1.890	4.598	0.999	0.998	1.001
67	1.969	4.605	1.000	1.000	1.000

TABLE 1(c) (CONT.)

Run 12194	X = 45.25 inches	Re_θ = 36760
P_o = 149.1 psia	T_∞ = 138.3 °R	δ^* = 0.410 inch
T_o = 749.6 °R	U_∞ = 2710 ft/sec	θ = 0.0726 inch
T_w = 523 °R	M_∞ = 4.71	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.782	0.	0.264
2	0.009	0.995	3.320	0.386	0.301
3	0.012	1.101	3.239	0.422	0.309
4	0.017	1.388	2.985	0.510	0.335
5	0.019	1.426	2.966	0.522	0.337
6	0.027	1.682	2.753	0.594	0.363
7	0.034	1.785	2.686	0.622	0.372
8	0.039	1.886	2.583	0.645	0.387
9	0.049	1.967	2.504	0.662	0.399
10	0.057	2.055	2.422	0.680	0.413
11	0.072	2.128	2.364	0.696	0.423
12	0.085	2.181	2.321	0.707	0.431
13	0.097	2.225	2.284	0.715	0.438
14	0.107	2.267	2.248	0.723	0.445
15	0.120	2.337	2.190	0.736	0.457
16	0.125	2.367	2.165	0.741	0.462
17	0.155	2.489	2.069	0.762	0.483
18	0.188	2.602	1.978	0.778	0.506
19	0.208	2.687	1.918	0.791	0.521
20	0.223	2.762	1.866	0.803	0.536
21	0.241	2.811	1.834	0.810	0.545
22	0.276	2.952	1.742	0.828	0.574
23	0.304	3.056	1.675	0.841	0.597
24	0.337	3.148	1.622	0.853	0.617
25	0.357	3.215	1.584	0.861	0.631
26	0.433	3.430	1.471	0.885	0.680
27	0.468	3.505	1.434	0.893	0.698
28	0.544	3.687	1.346	0.910	0.743
29	0.569	3.748	1.318	0.915	0.759
30	0.594	3.799	1.295	0.920	0.772
31	0.639	3.887	1.259	0.928	0.794
32	0.670	3.954	1.230	0.933	0.813
33	0.715	4.028	1.199	0.938	0.834
34	0.753	4.087	1.177	0.943	0.850
35	0.786	4.135	1.160	0.947	0.862
36	0.813	4.168	1.149	0.950	0.871
37	0.854	4.222	1.129	0.954	0.886
38	0.874	4.254	1.117	0.956	0.895
39	0.914	4.295	1.104	0.960	0.906
40	0.947	4.331	1.092	0.963	0.916
41	1.000	4.369	1.083	0.967	0.924
42	1.136	4.479	1.046	0.974	0.956
43	1.176	4.509	1.037	0.977	0.964
44	1.441	4.651	1.006	0.992	0.994
45	1.464	4.659	1.004	0.993	0.996
46	1.504	4.667	1.002	0.994	0.998
47	1.542	4.675	1.000	0.994	1.000
48	1.580	4.683	0.999	0.996	1.001
49	1.607	4.683	1.001	0.996	0.999
50	1.640	4.691	0.999	0.997	1.001
51	1.681	4.696	0.998	0.998	1.002
52	1.703	4.699	0.997	0.998	1.003
53	1.789	4.701	1.000	1.000	1.000

TABLE 1(d) (CONT.)

Run 12091	X = 57.25 inches	Re_θ = 5080
P_o = 14.4 psia	T_∞ = 143.0 °R	δ^* = 0.743 inch
T_o = 774.2 °R	U_∞ = 2754 ft/sec	θ = 0.109 inch
T_w = 520 °R	M_∞ = 4.70	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.635	0.	0.275
2	0.009	0.179	3.740	0.074	0.267
3	0.014	0.255	3.785	0.106	0.264
4	0.021	0.484	3.777	0.200	0.265
5	0.028	0.656	3.754	0.271	0.266
6	0.031	0.709	3.738	0.292	0.267
7	0.033	0.757	3.699	0.310	0.270
8	0.036	0.821	3.643	0.333	0.275
9	0.041	0.914	3.557	0.367	0.281
10	0.050	1.138	3.333	0.442	0.300
11	0.062	1.309	3.202	0.499	0.312
12	0.070	1.386	3.130	0.522	0.320
13	0.079	1.467	3.054	0.546	0.327
14	0.092	1.527	3.012	0.564	0.332
15	0.101	1.599	2.944	0.584	0.340
16	0.111	1.640	2.902	0.595	0.345
17	0.126	1.714	2.823	0.613	0.354
18	0.140	1.750	2.784	0.622	0.359
19	0.147	1.789	2.743	0.631	0.365
20	0.152	1.803	2.728	0.634	0.367
21	0.167	1.832	2.697	0.640	0.371
22	0.179	1.871	2.656	0.649	0.377
23	0.194	1.908	2.618	0.657	0.382
24	0.203	1.944	2.580	0.665	0.388
25	0.223	1.986	2.538	0.674	0.394
26	0.237	2.015	2.509	0.680	0.399
27	0.252	2.059	2.466	0.688	0.406
28	0.274	2.098	2.428	0.696	0.412
29	[illegible]	2.122	2.406	0.701	0.416
30	0.301	2.158	2.372	0.708	0.422
31	0.305	2.188	2.344	0.713	0.427
32	0.318	2.222	2.311	0.719	0.433
33	0.330	2.257	2.280	0.725	0.439
34	0.342	2.274	2.261	0.728	0.442
35	0.359	2.313	2.230	0.735	0.448
36	0.373	2.348	2.200	0.741	0.454
37	0.383	2.333	2.214	0.739	0.452
38	0.398	2.404	2.152	0.751	0.465
39	0.415	2.432	2.129	0.756	0.470
40	0.434	2.466	2.104	0.761	0.475
41	0.441	2.503	2.073	0.767	0.482
42	0.456	2.526	2.057	0.771	0.486
43	0.480	2.560	2.032	0.777	0.492
44	0.485	2.588	2.009	0.781	0.498
45	0.495	2.628	1.978	0.787	0.506
46	0.512	2.656	1.957	0.791	0.511
47	0.524	2.688	1.934	0.796	0.517
48	0.531	2.719	1.910	0.800	0.523
49	0.543	2.740	1.896	0.803	0.527
50	0.560	2.775	1.872	0.808	0.534
51	0.568	2.810	1.846	0.813	0.542
52	0.592	2.844	1.824	0.818	0.548
53	0.599	2.877	1.800	0.822	0.556
54	0.616	2.909	1.779	0.826	0.562
55	0.629	2.938	1.760	0.830	0.568
56	0.646	2.960	1.747	0.833	0.573
57	0.658	2.991	1.727	0.837	0.579
58	0.670	3.031	1.701	0.842	0.588
59	0.689	3.067	1.680	0.846	0.595
60	0.704	3.094	1.663	0.849	0.601
61	0.718	3.125	1.644	0.853	0.608
62	0.735	3.156	1.626	0.857	0.615
63	0.750	3.194	1.604	0.861	0.624
64	0.769	3.229	1.584	0.865	0.632
65	0.784	3.263	1.564	0.869	0.639
66	0.799	3.291	1.548	0.872	0.646
67	0.813	3.320	1.531	0.875	0.653
68	0.825	3.348	1.516	0.878	0.660
69	0.835	3.377	1.500	0.880	0.667
70	0.847	3.398	1.489	0.883	0.671
71	0.867	3.419	1.480	0.885	0.676
72	0.879	3.451	1.463	0.889	0.685

TABLE 1(e) (CONT.)

Run 12091 (Cont'd)

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
73	0.896	3.484	1.447	0.892	0.691
74	0.920	3.516	1.434	0.896	0.698
75	0.925	3.536	1.423	0.898	0.703
76	0.937	3.566	1.408	0.901	0.710
77	0.952	3.590	1.396	0.903	0.717
78	0.966	3.613	1.384	0.905	0.722
79	0.976	3.640	1.371	0.907	0.730
80	0.991	3.667	1.357	0.910	0.737
81	1.003	3.684	1.350	0.911	0.741
82	1.015	3.710	1.337	0.913	0.748
83	1.032	3.733	1.327	0.916	0.753
84	1.046	3.759	1.316	0.918	0.760
85	1.059	3.785	1.304	0.920	0.767
86	1.076	3.811	1.294	0.923	0.773
87	1.090	3.833	1.286	0.925	0.778
88	1.107	3.856	1.276	0.927	0.784
89	1.119	3.878	1.266	0.929	0.790
90	1.136	3.903	1.255	0.931	0.797
91	1.151	3.928	1.244	0.933	0.804
92	1.165	3.953	1.233	0.934	0.811
93	1.180	3.974	1.224	0.936	0.817
94	1.190	3.986	1.219	0.937	0.820
95	1.204	4.005	1.212	0.938	0.825
96	1.216	4.026	1.203	0.940	0.831
97	1.229	4.038	1.199	0.941	0.834
98	1.243	4.063	1.189	0.943	0.841
99	1.258	4.075	1.185	0.945	0.844
100	1.272	4.096	1.178	0.946	0.849
101	1.289	4.111	1.173	0.948	0.853
102	1.304	4.129	1.167	0.949	0.857
103	1.318	4.150	1.159	0.951	0.863
104	1.333	4.165	1.154	0.952	0.867
105	1.348	4.185	1.146	0.954	0.872
106	1.362	4.200	1.141	0.955	0.876
107	1.374	4.221	1.134	0.957	0.882
108	1.391	4.232	1.130	0.958	0.885
109	1.404	4.249	1.124	0.959	0.890
110	1.421	4.264	1.119	0.960	0.893
111	1.433	4.275	1.116	0.961	0.896
112	1.462	4.300	1.108	0.964	0.903
113	1.491	4.333	1.097	0.966	0.911
114	1.525	4.357	1.090	0.969	0.917
115	1.554	4.382	1.084	0.971	0.923
116	1.581	4.404	1.078	0.973	0.928
117	1.603	4.413	1.076	0.974	0.930
118	1.625	4.429	1.070	0.976	0.934
119	1.649	4.439	1.067	0.976	0.937
120	1.673	4.458	1.060	0.977	0.944
121	1.700	4.471	1.057	0.978	0.946
122	1.727	4.486	1.056	0.981	0.947
123	1.751	4.496	1.054	0.983	0.949
124	1.778	4.512	1.050	0.984	0.952
125	1.804	4.518	1.048	0.984	0.954
126	1.826	4.529	1.044	0.985	0.958
127	1.858	4.543	1.041	0.987	0.961
128	1.885	4.555	1.038	0.988	0.963
129	1.909	4.574	1.033	0.990	0.968
130	1.933	4.583	1.031	0.991	0.970
131	1.962	4.598	1.027	0.992	0.973
132	1.982	4.607	1.025	0.993	0.976
133	2.008	4.615	1.023	0.993	0.978
134	2.028	4.624	1.020	0.994	0.981
135	2.055	4.636	1.016	0.995	0.984
136	2.259	4.697	1.000	1.000	1.000

TABLE 1(f) (CONT.)

Run 12902	X = 57.25 inches	Re_θ = 21798
P_o = 75.7 psia	T_∞ = 140.9 °R	δ^* = 0.672 inch
T_o = 781.6 °R	U_∞ = 2775 ft/sec	θ = 0.0935 inch
T_w = 520 °R	M_∞ = 4.77	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.691	0.	0.271
2	0.015	0.948	3.409	0.367	0.293
3	0.022	1.338	3.106	0.494	0.322
4	0.027	1.388	3.113	0.513	0.321
5	0.032	1.446	3.105	0.534	0.322
6	0.037	1.492	3.060	0.547	0.327
7	0.042	1.520	3.044	0.556	0.329
8	0.050	1.581	2.978	0.572	0.336
9	0.060	1.624	2.930	0.583	0.341
10	0.065	1.649	2.902	0.589	0.345
11	0.070	1.680	2.868	0.597	0.349
12	0.082	1.729	2.817	0.608	0.355
13	0.090	1.767	2.776	0.617	0.360
14	0.100	1.797	2.745	0.624	0.364
15	0.129	1.877	2.676	0.644	0.374
16	0.162	1.962	2.600	0.663	0.385
17	0.169	1.995	2.569	0.670	0.389
18	0.194	2.062	2.510	0.685	0.398
19	0.227	2.162	2.420	0.705	0.413
20	0.231	2.169	2.414	0.707	0.414
21	0.254	2.248	2.343	0.721	0.427
22	0.271	2.287	2.310	0.729	0.433
23	0.309	2.391	2.226	0.748	0.449
24	0.321	2.435	2.190	0.756	0.457
25	0.333	2.456	2.176	0.760	0.460
26	0.346	2.500	2.140	0.767	0.467
27	0.368	2.546	2.103	0.774	0.475
28	0.398	2.612	2.052	0.784	0.487
29	0.423	2.677	2.003	0.794	0.499
30	0.433	2.714	1.974	0.800	0.507
31	0.455	2.758	1.943	0.806	0.515
32	0.483	2.830	1.892	0.816	0.529
33	0.488	2.844	1.882	0.818	0.531
34	0.518	2.918	1.831	0.828	0.546
35	0.530	2.947	1.811	0.832	0.552
36	0.547	2.992	1.782	0.838	0.561
37	0.575	3.031	1.759	0.843	0.569
38	0.580	3.065	1.737	0.847	0.576
39	0.592	3.107	1.709	0.852	0.585
40	0.605	3.133	1.694	0.855	0.590
41	0.607	3.141	1.689	0.856	0.592
42	0.647	3.233	1.634	0.867	0.612
43	0.659	3.261	1.618	0.870	0.618
44	0.689	3.321	1.584	0.877	0.631
45	0.692	3.330	1.579	0.877	0.633
46	0.724	3.398	1.542	0.885	0.648
47	0.739	3.431	1.525	0.888	0.656
48	0.779	3.515	1.482	0.897	0.675
49	0.789	3.532	1.475	0.899	0.678
50	0.824	3.608	1.438	0.907	0.695
51	0.663	3.681	1.406	0.915	0.711
52	0.928	3.792	1.357	0.926	0.737
53	0.985	3.895	1.310	0.935	0.763
54	1.013	3.933	1.294	0.938	0.773
55	1.080	4.044	1.246	0.947	0.802
56	1.120	4.100	1.223	0.951	0.817
57	1.152	4.142	1.207	0.954	0.828
58	1.199	4.202	[illegible]	0.959	0.845
59	1.242	4.249	[illegible]	0.962	0.858
60	1.294	4.299	1.148	0.966	0.871
61	1.326	4.332	1.136	0.968	0.880
62	1.346	4.358	1.126	0.970	0.888
63	1.386	4.398	1.112	0.972	0.899
64	1.421	4.428	1.101	0.974	0.908
65	1.478	4.454	1.092	0.976	0.916
66	1.508	4.478	1.082	0.977	0.923
67	1.543	4.510	1.072	0.979	0.933
68	1.568	4.534	1.063	0.980	0.941
69	1.575	4.531	1.064	0.980	0.940
70	1.607	4.547	1.059	0.981	0.944
71	1.612	4.561	1.054	0.982	0.949
72	1.625	4.561	1.054	0.982	0.948

TABLE 1(g)(CONT.)

Run 12092 (Cont'd)

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
73	1.662	4.589	1.046	0.984	0.956
74	1.675	4.588	1.047	0.984	0.955
75	1.692	4.606	1.042	0.986	0.960
76	1.714	4.608	1.043	0.987	0.959
77	1.742	4.622	1.042	0.989	0.960
78	1.754	4.635	1.039	0.991	0.963
79	1.787	4.642	1.041	0.993	0.961
80	1.819	4.667	1.034	0.995	0.967
81	1.844	4.673	1.033	0.996	0.968
82	1.866	4.690	1.027	0.997	0.974
83	1.891	4.698	1.025	0.997	0.976
84	1.906	4.702	1.023	0.997	0.977
85	1.919	4.709	1.021	0.993	0.979
86	1.943	4.720	1.017	0.998	0.985
87	1.983	4.731	1.014	0.999	0.986
88	2.023	4.742	1.010	0.999	0.990
89	2.090	4.758	1.004	1.000	0.996
90	2.125	4.769	1.000	1.000	1.000

TABLE 1(h) (CONT.)

Run 2021	X = 57.25 inches	Re_θ = 37367
P_o = 150.9	T_∞ = 131.0 °R	δ^* = 0.584 inch
T_o = 749.3 °R	U_∞ = 2725 ft/sec	θ = 0.0781 inch
T_w = 520 °R	M_∞ = 4.86	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.968	0.	0.252
2	0.009	1.042	3.444	0.398	0.290
3	0.020	1.293	3.285	0.483	0.304
4	0.025	1.339	3.287	0.500	0.304
5	0.042	1.590	3.101	0.576	0.322
6	0.061	1.769	2.896	0.620	0.345
7	0.080	1.881	2.780	0.646	0.360
8	0.096	1.963	2.698	0.664	0.371
9	0.110	2.005	2.658	0.673	0.376
10	0.121	2.041	2.623	0.680	0.381
11	0.132	2.070	2.596	0.687	0.385
12	0.153	2.127	2.556	0.700	0.391
13	0.172	2.222	2.466	0.718	0.406
14	0.227	2.380	2.324	0.747	0.430
15	0.303	2.531	2.203	0.773	0.454
16	0.306	2.610	2.153	0.785	0.469
17	0.322	2.660	2.093	0.793	0.478
18	0.344	2.732	2.038	0.803	0.491
19	0.360	2.775	2.007	0.809	0.498
20	0.377	2.839	1.959	0.818	0.511
21	0.401	2.893	1.921	0.826	0.521
22	0.420	2.943	1.886	0.832	0.530
23	0.439	2.999	1.847	0.839	0.541
24	0.464	3.074	1.797	0.848	0.557
25	0.488	3.139	1.755	0.856	0.570
26	0.510	3.188	1.724	0.862	0.580
27	0.526	3.233	1.696	0.867	0.590
28	0.548	3.299	1.657	0.874	0.603
29	0.567	3.342	1.632	0.879	0.613
30	0.589	3.388	1.605	0.884	0.623
31	0.608	3.443	1.574	0.889	0.635
32	0.641	3.502	1.543	0.896	0.648
33	0.649	3.550	1.516	0.900	0.660
34	0.673	3.600	1.489	0.904	0.672
35	0.698	3.662	1.456	0.910	0.687
36	0.717	3.701	1.437	0.913	0.696
37	0.739	3.743	1.417	0.917	0.706
38	0.758	3.769	1.405	0.920	0.712
39	0.780	3.810	1.385	0.923	0.722
40	0.793	3.841	1.371	0.926	0.729
41	0.818	3.893	1.347	0.930	0.743
42	0.837	3.921	1.334	0.932	0.750
43	0.856	3.967	1.313	0.936	0.761
44	0.875	3.988	1.305	0.938	0.766
45	0.894	4.024	1.289	0.940	0.776
46	0.910	4.059	1.274	0.943	0.785
47	0.943	4.100	1.258	0.947	0.795
48	0.951	4.124	1.247	0.948	0.802
49	0.976	4.161	1.232	0.951	0.812
50	0.995	4.179	1.225	0.952	0.816
51	1.014	4.213	1.212	0.955	0.825
52	1.036	4.233	1.205	0.957	0.830
53	1.055	4.263	1.194	0.959	0.837
54	1.076	4.297	1.181	0.961	0.847
55	1.098	4.327	1.169	0.963	0.855
56	1.120	4.344	1.164	0.965	0.859
57	1.139	4.374	1.153	0.967	0.867
58	1.155	4.396	1.145	0.968	0.874
59	1.177	4.417	1.137	0.970	0.880
60	1.199	4.425	1.135	0.971	0.881
61	1.221	4.474	1.118	0.974	0.895
62	1.242	4.492	1.111	0.975	0.900
63	1.264	4.509	1.106	0.976	0.905
64	1.283	4.525	1.100	0.977	0.909
65	1.302	4.546	1.093	0.979	0.915
66	1.324	4.557	1.090	0.980	0.917
67	1.343	4.578	1.084	0.981	0.923
68	1.362	4.599	1.077	0.983	0.928
69	1.379	4.612	1.073	0.984	0.932
70	1.400	4.625	1.068	0.984	0.936
71	1.419	4.638	1.065	0.985	0.939
72	1.439	4.659	1.058	0.987	0.945

TABLE 1(i) (CONT.)

Run 2021 (Cont'd)

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
73	1.458	4.666	1.056	0.987	0.947
74	1.477	4.669	1.056	0.988	0.947
75	1.498	4.692	1.049	0.989	0.953
76	1.520	4.695	1.049	0.990	0.954
77	1.534	4.700	1.047	0.990	0.955
78	1.561	4.725	1.039	0.992	0.962
79	1.583	4.748	1.031	0.993	0.970
80	1.605	4.770	1.025	0.994	0.976
81	1.901	4.857	1.000	1.000	1.000

TABLE 1(j)(CONT.)

Run 3141	X = 57.25 inches	Re_θ = 19213
P_o = 75.1 psia	T_∞ = 187.0 °R	δ^* = 0.656 inch
T_o = 1022.8 °R	U_∞ = 3169 ft/sec	θ = 0.124 inch
T_w = 517.5°R	M_∞ = 4.73	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.000	0.000	2.767	0.000	0.361
2	0.009	0.472	2.859	0.169	0.350
3	0.014	0.765	2.807	0.271	0.356
4	0.020	0.948	2.762	0.335	0.359
5	0.030	1.264	2.694	0.446	0.371
6	0.041	1.439	2.662	0.497	0.376
7	0.049	1.481	2.574	0.526	0.389
8	0.068	1.669	2.487	0.557	0.402
9	0.079	1.718	2.447	0.568	0.409
10	0.090	1.757	2.414	0.578	0.414
11	0.103	1.788	2.394	0.585	0.418
12	0.116	1.820	2.376	0.593	0.421
13	0.133	1.876	2.335	0.606	0.428
14	0.146	1.909	2.308	0.614	0.433
15	0.159	1.953	2.277	0.623	0.439
16	0.194	2.045	2.211	0.643	0.452
17	0.216	2.109	2.173	0.658	0.460
18	0.235	2.164	2.134	0.669	0.469
19	0.253	2.218	2.094	0.679	0.478
20	0.278	2.272	2.057	0.689	0.486
21	0.296	2.302	2.040	0.695	0.490
22	0.318	2.376	1.987	0.709	0.503
23	0.339	2.432	1.950	0.719	0.513
24	0.358	2.477	1.922	0.727	0.520
25	0.385	2.534	1.886	0.736	0.530
26	0.406	2.597	1.845	0.746	0.542
27	0.431	2.659	1.806	0.756	0.554
28	0.449	2.699	1.783	0.762	0.561
29	0.517	2.860	1.689	0.786	0.592
30	0.543	2.925	1.653	0.796	0.605
31	0.568	2.980	1.628	0.804	0.614
32	0.600	3.060	1.586	0.815	0.631
33	0.632	3.128	1.550	0.824	0.645
34	0.653	3.178	1.526	0.83	0.655
35	0.678	3.222	1.506	0.836	0.664
36	0.699	3.272	1.483	0.843	0.674
37	0.723	3.331	1.456	0.850	0.687
38	0.761	3.406	1.425	0.860	0.702
39	0.812	3.492	1.393	0.872	0.718
40	0.847	3.562	1.363	0.880	0.734
41	0.882	3.622	1.339	0.887	0.747
42	0.911	3.681	1.315	0.895	0.760
43	0.944	3.736	1.295	0.899	0.772
44	0.981	3.796	1.271	0.905	0.787
45	1.019	3.856	1.249	0.912	0.801
46	1.048	3.905	1.231	0.917	0.812
47	1.099	3.952	1.216	0.922	0.822
48	1.110	3.996	1.198	0.925	0.835
49	1.140	4.033	1.186	0.929	0.843
50	1.169	4.080	1.170	0.933	0.855
51	1.199	4.106	1.163	0.936	0.860
52	1.217	4.128	1.155	0.938	0.866
53	1.252	4.170	1.143	0.943	0.875
54	1.282	4.196	1.137	0.947	0.879
55	1.311	4.232	1.123	0.949	0.890
56	1.352	4.277	1.106	0.952	0.904
57	1.392	4.312	1.098	0.956	0.911
58	1.430	4.347	1.086	0.958	0.920
59	1.464	4.373	1.080	0.961	0.926
60	1.515	4.418	1.068	0.966	0.936
61	1.558	4.445	1.062	0.969	0.942
62	1.599	4.489	1.050	0.973	0.953
63	1.636	4.531	1.038	0.977	0.963
64	1.682	4.592	1.022	0.982	0.978
65	1.714	4.621	1.015	0.985	0.985
66	1.747	4.641	1.011	0.987	0.989
67	1.787	4.653	1.008	0.988	0.992
68	1.835	4.670	1.006	0.991	0.994
69	1.873	4.684	1.004	0.993	0.996
70	1.916	4.693	1.004	0.994	0.996
71	1.940	4.695	1.004	0.995	0.996
72	1.967	4.703	1.003	0.997	0.997
73	2.007	4.715	1.002	0.998	0.998
74	2.045	4.712	1.004	0.999	0.996
75	2.074	4.727	1.000	1.000	1.000

TABLE 1(k) (CONT.)

Run 3142	X = 57.25 inches	Re_θ = 17004
P_o = 75.4 psia	T_∞ = 216.7 °R	δ^* = 0.659 inch
T_o = 1175.8 °R	U_∞ = 3395 ft/sec	θ = 0.134 inch
T_w = 519.0 °R	M_∞ = 4.70	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	2.395	0.	0.418
2	0.014	0.531	2.617	0.183	0.382
3	0.017	0.639	2.627	0.220	0.381
4	0.019	0.801	2.594	0.274	0.386
5	0.025	1.008	2.568	0.343	0.389
6	0.027	1.173	2.497	0.394	0.401
7	0.035	1.363	2.463	0.455	0.406
8	0.044	1.471	2.470	0.492	0.405
9	0.049	1.563	2.404	0.515	0.416
10	0.057	1.623	2.364	0.531	0.423
11	0.068	1.698	2.312	0.549	0.433
12	0.081	1.738	2.289	0.559	0.437
13	0.092	1.769	2.269	0.566	0.441
14	0.103	1.800	2.251	0.574	0.444
15	0.116	1.832	2.241	0.583	0.446
16	0.129	1.878	2.214	0.594	0.452
17	0.143	1.928	2.180	0.605	0.459
18	0.164	1.976	2.155	0.617	0.464
19	0.183	2.037	2.116	0.630	0.473
20	0.202	2.097	2.077	0.642	0.481
21	0.234	2.173	2.031	0.658	0.492
22	0.261	2.229	1.998	0.670	0.500
23	0.277	2.284	1.961	0.680	0.510
24	0.296	2.342	1.923	0.691	0.520
25	0.315	2.389	1.895	0.699	0.528
26	0.344	2.456	1.857	0.711	0.539
27	0.363	2.505	1.829	0.720	0.547
28	0.385	2.554	1.805	0.729	0.554
29	0.419	2.627	1.768	0.743	0.566
30	0.462	2.699	1.735	0.756	0.576
31	0.476	2.764	1.694	0.765	0.590
32	0.527	2.875	1.634	0.781	0.612
33	0.564	2.968	1.585	0.794	0.631
34	0.594	3.031	1.554	0.803	0.644
35	0.621	3.089	1.527	0.811	0.655
36	0.645	3.146	1.500	0.819	0.666
37	0.672	3.193	1.480	0.826	0.676
38	0.704	3.260	1.450	0.835	0.689
39	0.731	3.318	1.425	0.842	0.702
40	0.761	3.375	1.400	0.849	0.714
41	0.782	3.411	1.386	0.854	0.722
42	0.820	3.482	1.358	0.863	0.736
43	0.860	3.546	1.332	0.870	0.751
44	0.900	3.616	1.306	0.878	0.766
45	0.959	3.716	1.271	0.890	0.787
46	1.008	3.788	1.246	0.899	0.802
47	1.040	3.848	1.224	0.905	0.817
48	1.104	3.928	1.199	0.914	0.834
49	1.153	3.990	1.179	0.921	0.848
50	1.196	4.044	1.163	0.927	0.860
51	1.222	4.081	1.152	0.931	0.868
52	1.263	4.117	1.142	0.935	0.875
53	1.303	4.166	1.127	0.940	0.887
54	1.330	4.195	1.119	0.943	0.894
55	1.375	4.244	1.105	0.948	0.905
56	1.410	4.284	1.093	0.952	0.915
57	1.451	4.312	1.087	0.956	0.920
58	1.486	4.343	1.079	0.959	0.927
59	1.518	4.365	1.075	0.962	0.931
60	1.566	4.406	1.065	0.967	0.939
61	1.596	4.421	1.063	0.969	0.940
62	1.631	4.439	1.061	0.972	0.942
63	1.668	4.470	1.055	0.976	0.948
64	1.700	4.494	1.048	0.978	0.954
65	1.730	4.521	1.041	0.981	0.961
66	1.762	4.554	1.032	0.983	0.969
67	1.802	4.606	1.016	0.987	0.984
68	1.845	4.632	1.011	0.990	0.989
69	1.883	4.649	1.007	0.992	0.993
70	1.918	4.660	1.005	0.993	0.995
71	1.966	4.672	1.004	0.995	0.996
72	2.007	4.678	1.004	0.997	0.996
73	2.041	4.698	0.999	0.998	1.001
74	2.068	4.704	0.999	0.999	1.001
75	2.101	4.704	1.000	1.000	1.000

TABLE 1(ℓ) (CONT.)

Run 12292
P_o = 14.1 psia
T_o = 608.1 °R
T_w = 526 °R

X = 69.25 inches
T_∞ = 112.3 °R
U_∞ = 2441 ft/sec
M_∞ = 4.70

Re_θ = 6580
δ^* = .930 inch
θ = .0982

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	4.684	0.	0.214
2	0.017	0.292	4.616	0.134	0.217
3	0.023	0.406	4.554	0.184	0.220
4	0.029	0.488	4.499	0.220	0.222
5	0.037	0.630	4.502	0.281	0.226
6	0.050	0.876	4.130	0.379	0.242
7	0.073	1.188	3.773	0.491	0.265
8	0.094	1.395	3.507	0.558	0.285
9	0.116	1.473	3.402	0.578	0.294
10	0.139	1.582	3.262	0.608	0.307
11	0.165	1.647	3.190	0.626	0.313
12	0.223	1.776	3.026	0.657	0.330
13	0.270	1.892	2.887	0.684	0.346
14	0.315	1.923	2.852	0.691	0.351
15	0.331	1.977	2.790	0.703	0.358
16	0.367	2.011	2.753	0.710	0.363
17	0.385	2.095	2.662	0.727	0.376
18	0.404	2.147	2.607	0.738	0.384
19	0.431	2.184	2.569	0.745	0.389
20	0.470	2.247	2.506	0.757	0.399
21	0.498	2.299	2.453	0.766	0.408
22	0.523	2.354	2.399	0.776	0.417
23	0.565	2.418	2.336	0.786	0.428
24	0.581	2.449	2.305	0.792	0.434
25	0.603	2.489	2.269	0.798	0.441
26	0.622	2.532	2.231	0.805	0.448
27	0.639	2.573	2.19.	0.811	0.456
28	0.683	2.668	2.110	0.825	0.474
29	0.713	2.730	2.057	0.833	0.486
30	0.742	2.767	2.026	0.838	0.494
31	0.790	2.854	1.957	0.850	0.511
32	0.822	2.922	1.905	0.858	0.525
33	0.864	3.004	1.844	0.868	0.542
34	0.940	3.154	1.738	0.885	0.575
35	0.963	3.203	1.705	0.890	0.586
36	1.047	3.323	1.634	0.904	0.612
37	1.117	3.443	1.562	0.916	0.640
38	1.144	3.511	1.521	0.922	0.658
39	1.184	3.587	1.478	0.928	0.677
40	1.218	3.641	1.448	0.933	0.690
41	1.321	3.880	1.326	0.951	0.754
42	1.485	4.102	1.224	0.966	0.817
43	1.668	4.232	1.168	0.974	0.856
44	1.725	4.278	1.120	0.976	0.869
45	2.085	4.595	1.034	0.994	0.967
46	2.326	4.698	1.000	1.000	1.000

TABLE 1(m) (CONT.)

Run 11221	X = 69.25 inches	Re_θ = 280[illegible]
P_o = 74.7 psia	T_∞ = 112.8 °R	δ^* = .708 inch
T_o = 596.7 °R	U_∞ = 2411 ft/sec	θ = .0742 inch
T_w = 530 °R	M_∞ = 4.63	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	4.699	0.	0.213
2	0.010	0.482	4.518	0.221	0.221
3	0.012	0.591	4.432	0.269	0.226
4	0.016	0.702	4.331	0.316	0.231
5	0.017	0.772	4.261	0.344	0.235
6	0.020	0.872	4.155	0.384	0.241
7	0.021	0.939	4.080	0.410	0.245
8	0.024	0.984	4.028	0.427	0.248
9	0.026	1.055	3.946	0.452	0.253
10	0.028	1.091	3.901	0.465	0.256
11	0.032	1.130	3.852	0.482	0.260
12	0.034	1.205	3.763	0.505	0.266
13	0.040	1.257	3.690	0.521	0.271
14	0.043	1.296	3.636	0.534	0.275
15	0.071	1.469	3.387	0.584	0.295
16	0.095	1.559	3.264	0.608	0.306
17	0.121	1.637	3.168	0.629	0.316
18	0.142	1.682	3.113	0.641	0.321
19	0.167	1.739	3.045	0.655	0.328
20	0.194	1.801	2.970	0.670	0.337
21	0.225	1.882	2.876	0.689	0.348
22	0.248	1.933	2.831	0.702	0.353
23	0.274	2.002	2.742	0.716	0.365
24	0.328	2.138	2.595	0.743	0.385
25	0.355	2.211	2.521	0.758	0.397
26	0.388	2.287	2.444	0.772	0.409
27	0.412	2.344	2.388	0.782	0.419
28	0.448	2.436	2.301	0.798	0.435
29	0.497	2.565	2.185	0.818	0.458
30	0.527	2.647	2.111	0.830	0.474
31	0.575	2.784	1.997	0.849	0.501
32	0.610	2.876	1.924	0.861	0.520
33	0.649	2.978	1.847	0.874	0.541
34	0.695	3.096	1.762	0.887	0.567
35	0.752	3.242	1.663	0.903	0.601
36	0.803	3.345	1.597	0.913	0.626
37	0.835	3.431	1.545	0.921	0.647
38	0.885	3.550	1.476	0.931	0.677
39	0.942	3.676	1.407	0.941	0.711
40	0.968	3.718	1.385	0.945	0.722
41	0.997	3.801	1.343	0.951	0.745
42	1.010	3.815	1.335	0.952	0.749
43	1.019	3.847	1.319	0.954	0.758
44	1.096	3.983	1.254	0.963	0.797
45	1.230	4.168	1.173	0.975	0.853
46	1.270	4.218	1.152	0.977	0.868
47	1.323	4.278	1.128	0.981	0.887
48	1.369	4.320	1.111	0.983	0.900
49	1.422	4.365	1.094	0.986	0.914
50	1.521	4.439	1.067	0.990	0.937
51	1.571	4.469	1.057	0.992	0.947
52	1.648	4.510	1.042	0.994	0.959
53	1.732	4.542	1.031	0.996	0.970
54	1.809	4.574	1.020	0.997	0.980
55	1.859	4.587	1.015	0.998	0.985
56	2.014	4.614	1.006	0.999	0.994
57	2.088	4.621	1.004	1.000	0.996
58	2.132	4.624	1.003	1.000	0.997
59	2.191	4.629	1.001	1.000	0.999
60	2.265	4.632	1.000	1.000	1.000

TABLE 1(n) (CONT.)

Run 11283	X = 69.25 inches	Re_θ = 49430
P_o = 148.7 psia	T_∞ = 107.1 °R	δ^* = .6[illegible] inch
T_o = 573.5 °R	U_∞ = 2367 ft/sec	θ = .0625 inch
T_w = 531 °R	M_∞ = 4.67	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	4.957	0.	0.202
2	0.008	0.828	4.355	0.370	0.230
3	0.010	0.949	4.178	0.416	0.239
4	0.014	1.076	4.008	0.462	0.250
5	0.016	1.132	3.930	0.481	0.254
6	0.020	1.264	3.831	0.505	0.251
7	0.028	1.338	3.657	0.548	0.273
8	0.037	1.409	3.561	0.570	0.281
9	0.045	1.457	3.499	0.584	0.286
10	0.054	1.487	3.467	0.593	0.288
11	0.069	1.587	3.376	0.625	0.296
12	0.083	1.642	3.264	0.636	0.306
13	0.098	1.701	3.186	0.651	0.314
14	0.127	1.775	3.091	0.669	0.324
15	0.139	1.824	3.027	0.680	0.330
16	0.153	1.865	2.977	0.690	0.336
17	0.196	1.988	2.835	0.718	0.353
18	0.218	2.057	2.760	0.732	0.362
19	0.236	2.106	2.708	0.743	0.369
20	0.265	2.198	2.611	0.761	0.383
21	0.291	2.263	2.545	0.774	0.393
22	0.357	2.431	2.380	0.804	0.420
23	0.381	2.486	2.328	0.813	0.429
24	0.422	2.611	2.212	0.832	0.452
25	0.449	2.700	2.135	0.845	0.468
26	0.489	2.821	2.031	0.862	0.492
27	0.532	2.946	1.930	0.877	0.518
28	0.584	3.079	1.845	0.896	0.542
29	0.606	3.142	1.781	0.899	0.562
30	0.638	3.204	1.735	0.905	0.576
31	0.706	3.359	1.633	0.920	0.612
32	0.817	3.689	1.435	0.947	0.697
33	0.868	3.778	1.386	0.953	0.721
34	0.954	3.929	1.310	0.964	0.763
35	1.002	4.047	1.252	0.971	0.798
36	1.002	4.051	1.251	0.971	0.799
37	1.005	4.047	1.249	0.969	0.801
38	1.089	4.192	1.181	0.977	0.846
39	1.150	4.281	1.142	0.980	0.876
40	1.212	4.340	1.116	0.983	0.896
41	1.314	4.429	1.081	0.987	0.925
42	1.391	4.506	1.052	0.991	0.950
43	1.440	4.515	1.048	0.991	0.954
44	1.496	4.552	1.036	0.993	0.965
45	1.554	4.582	1.025	0.994	0.975
46	1.681	4.621	1.012	0.996	0.988
47	1.758	4.632	1.008	0.997	0.992
48	1.853	4.653	1.003	0.999	0.997
49	1.921	4.658	1.000	0.998	1.000
50	1.983	4.648	1.005	0.999	0.995
51	2.044	4.666	1.000	1.000	1.000

TABLE 1(o) (CONT.)

Run 12086	X = 69.25 inches	Re_θ = 6030
P_o = 14.7 psia	T_∞ = 143.6 °R	δ^* = .869 inch
T_o = 762 °R	U_∞ = 2726 ft/sec	θ = .121 inch
T_w = 516 °R	M_∞ = 4.64	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.592	0.	0.278
2	0.013	0.232	3.718	0.096	0.269
3	0.018	0.302	3.754	0.126	0.266
4	0.032	0.519	3.812	0.219	0.262
5	0.045	0.786	3.662	0.324	0.273
6	0.052	0.907	3.571	0.369	0.280
7	0.066	1.153	3.333	0.454	0.300
8	0.081	1.349	3.129	0.514	0.320
9	0.096	1.485	2.984	0.553	0.335
10	0.122	1.602	2.860	0.584	0.350
11	0.144	1.697	2.760	0.608	0.362
12	0.154	1.739	2.715	0.618	0.368
13	0.166	1.768	2.686	0.625	0.372
14	0.193	1.815	2.638	0.635	0.379
15	0.220	1.868	2.584	0.647	0.387
16	0.256	1.920	2.534	0.659	0.395
17	0.283	1.980	2.477	0.672	0.404
18	0.317	2.027	2.433	0.681	0.411
19	0.343	2.074	2.390	0.691	0.418
20	0.368	2.124	2.344	0.701	0.427
21	0.387	2.169	2.304	0.710	0.434
22	0.409	2.199	2.279	0.716	0.439
23	0.431	2.237	2.247	0.723	0.445
24	0.455	2.284	2.208	0.732	0.453
25	0.475	2.319	2.177	0.738	0.459
26	0.494	2.369	2.134	0.746	0.449
27	0.516	2.386	2.122	0.749	0.471
28	0.538	2.436	2.081	0.758	0.481
29	0.567	2.491	2.040	0.767	0.490
30	0.601	2.550	1.995	0.777	0.501
31	0.623	2.584	1.970	0.782	0.508
32	0.654	2.661	1.914	0.793	0.523
33	0.681	2.708	1.881	0.800	0.532
34	0.718	2.768	1.837	0.809	0.544
35	0.749	2.826	1.794	0.816	0.557
36	0.778	2.881	1.756	0.823	0.569
37	0.803	2.928	1.725	0.829	0.580
38	0.827	2.985	1.688	0.836	0.592
39	0.851	3.031	1.660	0.842	0.602
40	0.878	3.082	1.629	0.848	0.614
41	0.902	3.134	1.598	0.854	0.626
42	0.924	3.169	1.578	0.858	0.634
43	0.951	3.226	1.548	0.865	0.544
44	0.980	3.273	1.527	0.872	0.655
45	1.012	3.329	1.501	0.879	0.666
46	1.038	3.375	1.481	0.885	0.675
47	1.057	3.433	1.454	0.692	0.688
48	1.094	3.478	1.433	0.897	0.698
49	1.118	3.517	1.412	0.901	0.708
50	1.150	3.573	1.388	0.907	0.721
51	1.179	3.625	1.367	0.913	0.732
52	1.206	3.669	1.345	0.917	0.743
53	1.237	3.723	1.320	0.922	0.758
54	1.276	3.775	1.299	0.927	0.770
55	1.301	3.818	1.283	0.932	0.779
56	1.335	3.869	1.263	0.937	0.792
57	1.361	3.913	1.245	0.941	0.803
58	1.391	3.954	1.227	0.944	0.815
59	1.422	3.997	1.210	0.947	0.827
60	1.461	4.045	1.193	0.952	0.838
61	1.485	4.073	1.184	0.955	0.845
62	1.507	4.101	1.175	0.958	0.851
63	1.548	4.140	1.161	0.962	0.861
64	1.573	4.170	1.150	0.964	0.870
65	1.592	4.194	1.140	0.965	0.877
66	1.616	4.212	1.134	0.967	0.882
67	1.641	4.242	1.124	0.969	0.890
68	1.675	4.264	1.117	0.971	0.895
69	1.699	4.294	1.108	0.974	0.903
70	1.731	4.314	1.102	0.976	0.907
71	1.757	4.335	1.096	0.978	0.912
72	1.784	4.350	1.092	0.980	0.916

TABLE 1(p) (CONT.)

Run 12086 (Cont'd)

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
73	1.811	4.370	1.086	0.982	0.921
74	1.838	4.385	1.082	0.983	0.924
75	1.867	4.403	1.077	0.985	0.929
76	1.889	4.419	1.073	0.987	0.932
77	1.923	4.440	1.067	0.988	0.938
78	1.957	4.454	1.063	0.990	0.941
79	1.981	4.469	1.058	0.991	0.945
80	2.010	4.477	1.057	0.992	0.946
81	2.042	4.496	1.051	0.994	0.951
82	2.068	4.504	1.049	0.994	0.953
83	2.110	4.520	1.044	0.995	0.956
84	2.141	4.530	1.041	0.996	0.961
85	2.166	4.537	1.037	0.996	0.964
86	2.197	4.545	1.033	0.995	0.968
87	2.219	4.546	1.031	0.995	0.970
88	2.238	4.560	1.025	0.995	0.976
89	2.260	4.574	1.019	0.995	0.982
90	2.513	4.671	0.987	1.000	1.013
91	2.518	4.650	0.994	0.999	1.006
92	2.532	4.654	0.993	1.000	1.007
93	2.545	4.652	0.994	1.000	1.006
94	2.552	4.650	0.995	1.000	1.005
95	2.566	4.645	0.998	1.000	1.002
96	2.581	4.639	1.000	1.000	1.000

TABLE 1(q) (CONT.)

Run 12085	X = 69.25 inches	Re_θ = 23881
P_o = 75.0 psia	T_∞ = 143.6 °R	δ^* = .676 inch
T_o = 775.4 °R	U_∞ = 2755 ft/sec	θ = .0986 inch
T_w = 520 °R	M_∞ = 4.69	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.622	0.	0.276
2	0.011	0.786	3.422	0.310	0.292
3	0.016	1.018	3.276	0.373	0.305
4	0.018	1.150	3.177	0.437	0.315
5	0.023	1.263	3.118	0.475	0.321
6	0.028	1.325	3.109	0.498	0.322
7	0.031	1.395	3.058	0.520	0.327
8	0.036	1.451	3.007	0.536	0.333
9	0.048	1.514	2.944	0.554	0.340
10	0.056	1.557	2.900	0.565	0.345
11	0.066	1.590	2.867	0.574	0.349
12	0.078	1.639	2.818	0.586	0.355
13	0.108	1.716	2.744	0.606	0.364
14	0.133	1.790	2.672	0.624	0.374
15	0.186	1.910	2.564	0.652	0.390
16	0.228	2.030	2.454	0.678	0.408
17	0.266	2.110	2.388	0.695	0.419
18	0.291	2.182	2.330	0.710	0.429
19	0.318	2.275	2.256	0.729	0.443
20	0.348	2.326	2.222	0.739	0.450
21	0.391	2.417	2.156	0.757	0.464
22	0.411	2.491	2.098	0.769	0.477
23	0.451	2.557	2.053	0.781	0.487
24	0.488	2.656	1.980	0.797	0.505
25	0.523	2.747	1.914	0.810	0.523
26	0.560	2.835	1.852	0.823	0.540
27	0.590	2.920	1.795	0.834	0.557
28	0.620	3.005	1.739	0.845	0.575
29	0.658	3.096	1.682	0.856	0.595
30	0.678	3.141	1.654	0.861	0.605
31	0.700	3.198	1.619	0.868	0.618
32	0.723	3.250	1.588	0.873	0.630
33	0.750	3.313	1.553	0.880	0.644
34	0.768	3.356	1.529	0.885	0.654
35	0.798	3.426	1.491	0.892	0.671
36	0.843	3.526	1.439	0.902	0.695
37	0.860	3.572	1.416	0.906	0.706
38	0.910	3.668	1.369	0.915	0.731
39	0.938	3.720	1.343	0.919	0.744
40	0.962	3.767	1.321	0.923	0.757
41	0.990	3.822	1.295	0.927	0.772
42	1.017	3.854	1.282	0.930	0.780
43	1.035	3.884	1.268	0.933	0.788
44	1.060	3.931	1.248	0.936	0.801
45	1.097	4.012	1.215	0.943	0.823
46	1.155	4.076	1.194	0.949	0.838
47	1.172	4.111	1.181	0.953	0.846
48	1.210	4.167	1.163	0.958	0.860
49	1.242	4.210	1.150	0.963	0.869
50	1.277	4.250	1.136	0.966	0.880
51	1.355	4.338	1.106	0.973	0.904
52	1.422	4.395	1.085	0.976	0.921
53	1.487	4.450	1.066	0.980	0.938
54	1.544	4.497	1.051	0.983	0.952
55	1.602	4.537	1.037	0.985	0.964
56	1.632	4.554	1.032	0.986	0.969
57	1.664	4.574	1.025	0.987	0.975
58	1.704	4.588	1.021	0.988	0.980
59	1.737	4.605	1.015	0.989	0.985
60	1.764	4.611	1.013	0.989	0.987
61	1.854	4.633	1.005	0.990	0.995
62	1.926	4.645	1.001	0.991	0.999
63	2.019	4.659	1.008	0.997	0.992
64	2.076	4.670	1.006	0.999	0.994
65	2.129	4.672	1.005	0.999	0.995
66	2.251	4.683	1.002	0.999	0.998
67	2.334	4.689	1.001	1.000	0.999
68	2.384	4.691	1.000	1.000	1.000

TABLE 1(r) (CONT.)

Run 6211	X = 69.25 inches	Re_θ = 56737
P_o = 149.7 psia	T_∞ = 138.1 °R	δ^* = .706 inch
T_o = 741.5 °R	U_∞ = 2692 ft/sec	θ = .108 inch
T_w = 534 °R	M_∞ = 4.67	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.865	0.	0.259
2	0.008	0.707	3.604	0.287	0.277
3	0.012	0.85	3.462	0.357	0.289
4	0.017	1.06[illegible]	3.322	[illegible]	0.301
5	0.025	1.218	3.203	0.466	0.312
6	0.034	1.378	3.154	0.524	0.317
7	0.038	1.423	3.109	0.537	0.322
8	0.042	1.466	3.064	0.549	0.326
9	0.047	1.492	3.039	0.557	0.329
10	0.060	1.534	3.002	0.569	0.333
11	0.073	1.591	2.945	0.584	0.340
12	0.090	1.639	2.895	0.597	0.345
13	0.107	1.685	2.845	0.608	0.352
14	0.120	1.723	2.803	0.618	0.357
15	0.142	1.760	2.764	0.626	0.362
16	0.155	1.788	2.733	0.633	0.366
17	0.172	1.830	2.688	0.642	0.372
18	0.193	1.879	2.637	0.653	0.379
19	0.215	1.925	2.589	0.663	0.386
20	0.237	1.977	2.536	0.674	0.394
21	0.258	2.030	2.483	0.685	0.403
22	0.284	2.102	2.414	0.699	0.414
23	0.327	2.197	2.325	0.717	0.430
24	0.344	2.270	2.258	0.730	0.443
25	0.422	2.423	2.125	0.756	0.470
26	0.474	2.544	2.026	0.775	0.494
27	0.530	2.688	1.918	0.797	0.521
28	0.586	2.818	1.823	0.814	0.548
29	0.638	2.953	1.732	0.832	0.577
30	0.672	3.033	1.680	0.841	0.595
31	0.750	3.192	1.586	0.860	0.630
32	0.840	3.420	1.462	0.885	0.684
33	0.931	3.590	1.380	0.902	0.725
34	1.021	3.754	1.305	0.918	0.766
35	1.107	3.901	1.242	0.930	0.805
36	1.181	4.008	1.198	0.939	0.835
37	1.250	4.109	1.160	0.947	0.862
38	1.323	4.193	1.130	0.954	0.885
39	1.392	4.267	1.104	0.959	0.906
40	1.457	4.328	1.086	0.965	0.921
41	1.521	4.385	1.069	0.970	0.935
42	1.577	4.461	1.044	0.975	0.958
43	1.664	4.523	1.027	0.981	0.973
44	1.746	4.559	1.021	0.986	0.979
45	1.823	4.597	1.012	0.990	0.988
46	1.879	4.616	1.009	0.992	0.991
47	1.961	4.638	1.005	0.995	0.995
48	2.035	4.659	1.000	0.997	1.000
49	2.095	4.675	0.997	0.999	1.003
50	2.160	4.673	1.000	1.000	1.000

TABLE 1(s) (CONT.)

Run 3131	X = 69.25 inches	Re_θ = 19040
P_o = 74.6 psia	T_∞ = 180.6 °R	δ^* = .657 inch
T_o = 1004.6 °R	U_∞ = 3146 ft/sec	θ = .123 inch
T_w = 509 °R	M_∞ = 4.78	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	2.819	0.	0.355
2	0.022	0.738	2.912	0.264	0.343
3	0.025	0.833	2.886	0.296	0.346
4	0.033	1.135	2.814	0.399	0.355
5	0.035	1.265	2.703	0.436	0.370
6	0.043	1.421	2.633	0.483	0.380
7	0.051	1.531	2.596	0.517	0.385
8	0.059	1.603	2.545	0.535	0.393
9	0.070	1.687	2.478	0.556	0.404
10	0.084	1.735	2.445	0.568	0.409
11	0.097	1.774	2.423	0.578	0.413
12	0.108	1.806	2.409	0.587	0.415
13	0.118	1.833	2.389	0.593	0.419
14	0.132	1.861	2.370	0.600	0.422
15	0.143	1.897	2.343	0.608	0.427
16	0.156	1.934	2.318	0.616	0.431
17	0.164	1.949	2.308	0.620	0.433
18	0.183	2.005	2.268	0.632	0.441
19	0.204	2.058	2.230	0.643	0.449
20	0.223	2.104	2.197	0.653	0.455
21	0.255	2.181	2.147	0.669	0.466
22	0.276	2.212	2.129	0.676	0.470
23	0.298	2.267	2.091	0.686	0.476
24	0.317	2.320	2.053	0.696	0.487
25	0.343	2.378	2.016	0.707	0.496
26	0.373	2.451	1.967	0.720	0.508
27	0.400	2.517	1.925	0.731	0.519
28	0.429	2.581	1.887	0.742	0.530
29	0.453	2.650	1.844	0.753	0.542
30	0.483	2.716	1.807	0.764	0.553
31	0.507	2.785	1.765	0.775	0.567
32	0.533	2.839	1.736	0.783	0.576
33	0.560	2.900	1.702	0.792	0.588
34	0.587	2.965	1.668	0.802	0.600
35	0.611	3.029	1.632	0.810	0.613
36	0.638	3.100	1.594	0.819	0.627
37	0.673	3.178	1.555	0.830	0.643
38	0.697	3.233	1.528	0.837	0.655
39	0.721	3.290	1.500	0.844	0.667
40	0.753	3.363	1.465	0.852	0.682
41	0.774	3.419	1.439	0.858	0.695
42	0.801	3.466	1.418	0.864	0.705
43	0.825	3.524	1.392	0.870	0.719
44	0.849	3.573	1.370	0.876	0.730
45	0.882	3.635	1.345	0.882	0.744
46	0.911	3.712	1.312	0.890	0.762
47	0.954	3.790	1.281	0.898	0.781
48	1.013	3.896	1.242	0.909	0.605
49	1.048	3.962	1.216	0.914	0.823
50	1.107	4.060	1.180	0.924	0.847
51	1.147	4.134	1.156	0.930	0.865
52	1.192	4.207	1.132	0.937	0.883
53	1.254	4.287	1.110	0.945	0.901
54	1.294	4.334	1.097	0.950	0.911
55	1.353	4.405	1.079	0.958	0.927
56	1.396	4.447	1.069	0.962	0.936
57	1.439	4.483	1.060	0.966	0.944
58	1.492	4.526	1.048	0.970	0.955
59	1.551	4.556	1.042	0.973	0.960
60	1.578	4.576	1.037	[illegible]	0.965
61	1.615	4.597	1.032	0.978	0.969
62	1.655	4.613	1.029	0.980	0.971
63	1.706	4.641	1.024	0.983	0.977
64	1.787	4.690	1.011	0.987	0.989
65	1.830	4.701	1.009	0.989	0.991
66	1.875	4.718	1.006	0.991	0.994
67	1.926	4.732	1.005	0.993	0.995
68	1.990	4.760	1.000	0.996	1.000
69	2.068	4.765	1.001	0.998	0.999
70	2.135	4.771	1.000	0.999	1.000
71	2.191	4.777	1.000	1.000	1.000

TABLE 1(t) (CONT.)

Run 3132	X = 69.25 inches	Re_θ = 15083
P_o = 75.0 psia	T_∞ = 187.7 °R	δ^* = .680 inch
T_o = 1094.2 °R	U_∞ = 3300 ft/sec	θ = .1174 inch
T_w = 515 °R	M_∞ = 4.91	

1	0.	0.	2.743	0.	0.365
2	0.020	0.836	2.825	0.286	0.354
3	0.023	0.922	2.812	0.315	0.356
4	0.025	1.044	2.763	0.353	0.362
5	0.031	1.224	2.701	0.410	0.370
6	0.033	1.362	2.603	0.447	0.384
7	0.039	1.466	2.525	0.474	0.396
8	0.044	1.563	2.453	0.498	0.408
9	0.047	1.628	2.402	0.514	0.416
10	0.057	1.716	2.406	0.542	0.416
11	0.063	1.783	2.388	0.561	0.419
12	0.074	1.823	2.437	0.579	0.410
13	0.084	1.855	2.432	0.589	0.411
14	0.111	1.932	2.398	0.609	0.417
15	0.146	2.021	2.344	0.630	0.427
16	0.165	2.065	2.323	0.640	0.430
17	0.167	2.086	2.307	0.645	0.433
18	0.197	2.148	2.286	0.661	0.437
19	0.213	2.201	2.247	0.672	0.445
20	0.240	2.266	2.206	0.685	0.453
21	0.266	2.342	2.154	0.700	0.464
22	0.293	2.385	2.131	0.709	0.469
23	0.328	2.481	2.066	0.726	0.484
24	0.347	2.516	2.046	0.732	0.489
25	0.368	2.567	2.014	0.741	0.497
26	0.395	2.623	1.980	0.751	0.505
27	0.411	2.667	1.952	0.758	0.512
28	0.435	2.721	1.923	0.768	0.520
29	0.454	2.763	1.901	0.775	0.526
30	0.473	2.800	1.880	0.781	0.532
31	0.483	2.826	1.864	0.785	0.536
32	0.505	2.892	1.822	0.794	0.549
33	0.521	2.927	1.801	0.799	0.555
34	0.539	2.961	1.784	0.805	0.561
35	0.556	3.000	1.763	0.811	0.567
36	0.574	3.058	1.730	0.819	0.578
37	0.588	3.091	1.712	0.823	0.584
38	0.601	3.119	1.698	0.827	0.589
39	0.620	3.165	1.673	0.833	0.598
40	0.633	3.201	1.653	0.838	0.605
41	0.647	3.233	1.637	0.842	0.611
42	0.660	3.260	1.624	0.846	0.616
43	0.706	3.373	1.567	0.860	0.638
44	0.730	3.431	1.540	0.867	0.649
45	0.764	3.506	1.506	0.876	0.664
46	0.810	3.628	1.450	0.889	0.690
47	0.842	3.684	1.427	0.896	0.701
48	0.677	3.761	1.395	0.904	0.717
49	0.914	3.851	1.359	0.914	0.736
50	0.955	3.936	1.325	0.922	0.755
51	0.989	3.994	1.304	0.928	0.767
52	1.054	4.112	1.263	0.941	0.792
53	1.096	4.172	1.244	0.947	0.804
54	1.129	4.237	1.222	0.953	0.818
55	1.161	4.280	1.208	0.958	0.828
56	1.201	4.341	1.189	0.963	0.841
57	1.241	4.374	1.180	0.967	0.847
58	1.273	4.427	1.163	0.972	0.860
59	1.308	4.462	1.153	0.975	0.868
60	1.346	4.506	1.140	0.979	0.877
61	1.364	4.525	1.136	0.981	0.881
62	1.399	4.554	1.128	0.984	0.887
63	1.431	4.579	1.121	0.987	0.892
64	1.463	4.605	1.114	0.989	0.898
65	1.487	4.626	1.107	0.990	0.903
66	1.530	4.663	1.100	0.995	0.909
67	1.570	4.691	1.092	0.998	0.916
68	1.600	4.708	1.090	1.000	0.916
69	1.632	4.724	1.088	1.003	0.919
70	1.667	4.746	1.083	1.005	0.923
71	1.723	4.758	1.084	1.008	0.923
72	1.753	4.788	1.076	1.011	0.929

TABLE 1(u) (CONT.)

Run 3132 (Cont'd)

73	1.787	4.807	1.071	1.013	0.934
74	1.870	4.845	1.046	1.009	0.956
75	1.937	4.869	1.053	1.017	0.950
76	1.983	4.869	1.049	1.015	0.953
77	2.031	4.892	1.017	1.004	0.983
78	2.074	4.898	0.980	0.987	1.020
79	2.125	4.907	0.983	0.990	1.017
80	2.157	4.913	1.014	1.007	0.986
81	2.189	4.916	1.017	1.009	0.983
82	2.213	4.913	1.000	1.000	1.000

TABLE 1(v) (CONT.)

Run 12201	X = 91.25 inches	Re_θ = 8938
P_o = 14.9 psia	T_∞ = 148.3 °R	δ^* = 1.199 inch
T_o = 772.6 °R	U_∞ = 2739 ft/sec	θ = .176 inch
T_w = 517 °R	M_∞ = 4.59	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.487	0.	0.287
2	0.020	0.306	3.615	0.127	0.277
3	0.024	0.400	3.615	0.166	0.277
4	0.024	0.388	3.621	0.161	0.276
5	0.033	0.499	3.635	0.208	0.275
6	0.033	0.499	3.635	0.208	0.275
7	0.037	0.559	3.617	0.232	0.276
8	0.042	0.657	3.574	0.271	0.280
9	0.051	0.776	3.509	0.317	0.285
10	0.059	0.873	3.444	0.353	0.290
11	0.068	1.065	3.275	0.420	0.305
12	0.081	1.160	3.188	0.452	0.314
13	0.090	1.248	3.105	0.479	0.322
14	0.103	1.328	3.025	0.503	0.331
15	0.112	1.390	2.961	0.521	0.338
16	0.129	1.492	2.857	0.550	0.350
17	0.160	1.598	2.750	0.577	0.364
18	0.2	1.683	2.665	0.599	0.375
19	0.247	1.718	2.631	0.607	0.380
20	0.265	1.750	2.599	0.615	0.385
21	0.326	1.824	2.531	0.632	0.395
22	0.374	1.874	2.485	0.644	0.402
23	0.466	2.007	2.357	0.672	0.424
24	0.523	2.075	2.303	0.686	0.434
25	0.554	2.088	2.297	0.690	0.435
26	0.593	2.125	2.268	0.698	0.441
27	0.628	2.163	2.238	0.705	0.447
28	0.680	2.226	2.186	0.717	0.457
29	0.742	2.294	2.130	0.730	0.469
30	0.825	2.380	2.065	0.745	0.484
31	0.890	2.459	2.003	0.759	0.499
32	0.921	2.498	1.977	0.766	0.506
33	0.943	2.531	1.954	0.771	0.512
34	1.039	2.628	1.890	0.788	0.529
35	1.109	2.736	1.817	0.804	0.550
36	1.170	2.799	1.778	0.814	0.562
37	1.236	2.873	1.734	0.825	0.577
38	1.314	2.978	1.673	0.839	0.598
39	1.398	3.096	1.605	0.855	0.623
40	1.463	3.194	1.550	0.866	0.645
41	1.538	3.302	1.491	0.879	0.671
42	1.612	3.413	1.434	0.891	0.697
43	1.682	3.527	1.379	0.902	0.725
44	1.796	3.689	1 305	0.919	0.766
45	1.857	3.788	1.263	0.928	0.792
46	1.927	3.881	1.227	0.937	0.815
47	1.997	3.991	1.183	0.946	0.846
48	2.062	4.078	1.148	0.952	0.871
49	2.150	4.185	1.106	0.959	0.904
50	2.425	4.413	1.039	0.981	0.962
51	2.487	4.446	1.031	0.984	0.970
52	2.561	4.465	1.023	0.989	0.977
53	2.640	4.517	1.019	0.994	0.981
54	2.766	4.558	1.005	0.996	0.995
55	2.822	4.568	0.999	0.995	1.001
56	2.906	4.578	1.001	0.998	0.999
57	2.963	4.587	1.001	1.000	0.999
58	3.020	4.588	1.000	1.000	1.000

TABLE 1(w) (CONT.)

Run 12198	X = 91.25 inches	Re_{θ} = 28040
P_o = 74.6 psia	T_{∞} = 142.1 °R	δ^* = .760 inch
T_o = 784.1 °R	U_{∞} = 2777 ft/sec	θ = .121
T_w = 517 °R	M_{∞} = 4.75	

No.	Y(inches)	M	T/T_{∞}	U/U_{∞}	ρ/ρ_{∞}
1	0.	0.	3.710	0.	0.275
2	0.011	0.853	3.450	0.330	0.296
3	0.014	0.946	3.397	0.363	0.300
4	0.019	1.082	3.327	0.411	0.307
5	0.026	1.274	3.213	0.476	0.318
6	0.031	1.368	3.167	0.507	0.322
7	0.041	1.436	3.100	0.527	0.329
8	0.056	1.527	3.001	0.551	0.340
9	0.069	1.579	2.949	0.565	0.344
10	0.084	1.579	2.956	0.566	0.345
11	0.094	1.662	2.868	0.587	0.356
12	0.096	1.662	2.869	0.587	0.356
13	0.106	1.702	2.828	0.596	0.361
14	0.114	1.718	2.812	0.600	0.363
15	0.126	1.757	2.772	0.610	0.368
16	0.131	1.748	2.783	0.608	0.367
17	0.144	1.795	2.737	0.619	0.373
18	0.159	1.823	2.712	0.626	0.376
19	0.161	1.832	2.704	0.628	0.377
20	0.176	1.853	2.685	0.633	0.380
21	0.181	1.867	2.671	0.636	0.382
22	0.196	1.896	2.641	0.642	0.386
23	0.226	1.952	2.592	0.655	0.394
24	0.256	2.012	2.538	0.668	0.402
25	0.276	2.058	2.495	0.677	0.409
26	0.309	2.115	2.442	0.689	0.418
27	0.344	2.183	2.383	0.702	0.428
28	0.374	2.237	2.341	0.713	0.436
29	0.394	2.279	2.306	0.721	0.442
30	0.426	2.342	2.255	0.733	0.453
31	0.456	2.387	2.218	0.741	0.460
32	0.491	2.458	2.161	0.753	0.472
33	0.524	2.522	2.111	0.764	0.483
34	0.539	2.548	2.092	0.768	0.488
35	0.574	2.598	2.056	0.776	0.496
36	0.594	2.664	2.006	0.786	0.509
37	0.619	2.713	1.972	0.794	0.517
38	0.649	2.766	1.936	0.802	0.527
39	0.669	2.821	1.896	0.809	0.538
40	0.699	2.882	1.855	0.818	0.550
41	0.719	2.923	1.829	0.823	0.558
42	0.741	2.972	1.796	0.830	0.568
43	0.756	3.007	1.773	0.835	0.575
44	0.781	3.064	1.737	0.841	0.587
45	0.806	3.115	1.705	0.847	0.599
46	0.834	3.177	1.667	0.855	0.612
47	0.851	3.210	1.648	0.859	0.619
48	0.891	3.303	1.595	0.869	0.640
49	0.919	3.370	1.557	0.876	0.655
50	0.944	3.417	1.532	0.881	0.666
51	0.969	3.471	1.503	0.887	0.679
52	0.989	3.524	1.476	0.892	0.692
53	1.014	3.568	1.452	0.896	0.703
54	1.034	3.623	1.424	0.901	0.717
55	1.059	3.678	1.398	0.906	0.730
56	1.076	3.713	1.382	0.909	0.739
57	1.104	3.763	1.360	0.914	0.750
58	1.119	3.805	1.341	0.918	0.761
59	1.136	3.839	1.324	0.921	0.770
60	1.151	3.870	1.311	0.923	0.778
61	1.174	3.911	1.294	0.927	0.783
62	1.194	3.948	1.278	0.930	0.798
63	1.214	3.996	1.257	0.933	0.812
64	1.239	4.039	1.239	0.937	0.824
65	1.256	4.078	1.222	0.939	0.835
66	1.279	4.117	1.207	0.942	0.845
67	1.306	4.155	1.193	0.945	0.856
68	1.324	4.193	1.178	0.948	0.866
69	1.341	4.221	1.167	0.950	0.874
70	1.351	4.234	1.162	0.951	0.878
71	1.374	4.268	1.150	0.954	0.887
72	1.399	4.305	1.137	0.956	0.897

TABLE 1(x) (CONT.)

Run 12198 (Cont'd)

No.	Y(inches)	M	T/T_∞	$\bar{U}/U_\infty$	ρ/ρ_∞
73	1.419	4.339	1.124	0.959	0.907
74	1.444	4.366	1.115	0.961	0.915
75	1.471	4.399	1.104	0.963	0.924
76	1.491	4.420	1.097	0.965	0.930
77	1.524	4.449	1.087	0.966	0.939
78	1.559	4.491	1.072	0.969	0.951
79	1.589	4.520	1.063	0.971	0.960
80	1.611	4.540	1.057	0.972	0.966
81	1.641	4.555	1.052	0.974	0.970
82	1.691	4.598	1.039	0.977	0.982
83	1.731	4.618	1.034	0.978	0.988
84	1.769	4.635	1.029	0.980	0.992
85	1.801	4.655	1.022	0.981	0.998
86	1.826	4.664	1.020	0.982	1.000
87	1.856	4.681	1.016	0.983	1.004
88	1.899	4.692	1.012	0.984	1.008
89	1.956	4.709	1.008	0.985	1.012
90	1.981	4.712	1.008	0.986	1.012
91	2.016	4.721	1.006	0.987	1.014
92	2.074	4.727	1.005	0.987	1.015
93	2.159	4.740	1.001	0.988	1.020
94	2.229	4.743	1.000	0.988	1.020
95	2.279	4.743	1.000	0.988	1.020
96	2.326	4.743	1.000	0.991	1.015
97	2.369	4.740	1.000	0.995	1.005
98	2.449	4.740	1.000	1.000	0.996
99	2.451	4.751	1.000	1.000	1.000

TABLE 1(y)(CONT.)

Run 12197	X = 91.25 inches	Re_θ = 51518
P_o = 150.3 psia	T_∞ = 133.9 °R	δ^* = .799 inch
T_o = 735.2 °R	U_∞ = 2688 ft/sec	θ = .111 inch
T_w = 517 °R	M_∞ = 4.74	

No.	Y(inches)	M	T/T_∞	U/U_∞	ρ/ρ_∞
1	0.	0.	3.861	0.	0.259
2	0.008	0.941	3.407	0.367	0.293
3	0.008	0.977	3.374	0.379	0.296
4	0.012	1.041	3.339	0.402	0.299
5	0.017	1.127	3.281	0.431	0.305
6	0.017	1.204	3.200	0.455	0.313
7	0.021	1.275	3.152	0.478	0.317
8	0.025	1.320	3.131	0.493	0.319
9	0.025	1.385	3.060	0.511	0.327
10	0.030	1.436	3.030	0.528	0.330
11	0.034	1.485	3.002	0.543	0.333
12	0.043	1.533	2.972	0.558	0.336
13	0.052	1.597	2.905	0.574	0.344
14	0.065	1.632	2.872	0.584	0.348
15	0.074	1.666	2.837	0.592	0.352
16	0.109	1.757	2.752	0.615	0.363
17	0.144	1.844	2.678	0.637	0.373
18	0.174	1.896	2.634	0.649	0.380
19	0.205	1.954	2.580	0.662	0.388
20	0.231	2.011	2.527	0.675	0.396
21	0.262	2.047	2.497	0.683	0.401
22	0.292	2.107	2.443	0.695	0.409
23	0.314	2.146	2.408	0.703	0.415
24	0.367	2.206	2.360	0.715	0.424
25	0.358	2.230	2.335	0.719	0.428
26	0.393	2.286	2.268	0.730	0.437
27	0.428	2.340	2.244	0.740	0.446
28	0.463	2.406	2.192	0.752	0.456
29	0.498	2.463	2.149	0.762	0.465
30	0.537	2.547	2.083	0.776	0.480
31	0.581	2.618	2.032	0.788	0.492
32	0.612	2.671	1.993	0.796	0.502
33	0.646	2.748	1.937	0.807	0.516
34	0.681	2.799	1.904	0.815	0.525
35	0.721	2.883	1.847	0.827	0.541
36	0.765	2.964	1.793	0.838	0.558
37	0.804	3.039	1.744	0.847	0.573
38	0.835	3.098	1.707	0.854	0.586
39	0.856	3.174	1.660	0.863	0.603
40	0.900	3.235	1.627	0.871	0.615
41	0.940	3.300	1.591	0.878	0.629
42	0.974	3.383	1.543	0.887	0.648
43	1.005	3.445	1.510	0.893	0.662
44	1.053	3.545	1.457	0.903	0.686
45	1.079	3.604	1.427	0.909	0.701
46	1.141	3.726	1.367	0.920	0.731
47	1.198	3.837	1.316	0.929	0.760
48	1.254	3.945	1.268	0.937	0.789
49	1.311	4.054	1.222	0.946	0.818
50	1.346	4.106	1.200	0.950	0.833
51	1.407	4.166	1.160	0.955	0.848
52	1.486	4.321	1.120	0.965	0.893
53	1.552	4.442	1.077	0.973	0.928
54	1.731	4.557	1.046	0.984	0.956
55	1.875	4.649	1.018	0.990	0.982
56	1.954	4.676	1.013	0.993	0.988
57	2.033	4.703	1.008	0.996	0.992
58	2.112	4.723	1.005	0.999	0.995
59	2.190	4.726	1.006	1.001	0.994
60	2.256	4.732	1.006	1.002	0.994
61	2.330	4.738	1.000	00	1.000

TABLE 2

SUMMARY OF HEAT TRANSFER DATA

$\bar{x}$ inches	p_o psia	T_o °R	T_w °R	$\dot{q}$ Btu/ft^2-sec	Re_θ	St x 10^4	C_{f_H} x 10^4	C_{f_B} x 10^4 *	$\frac{2\,St}{C_{f_B}}$
60	15	785	530	.052	5160	5.56	8.85	8.9	1.249
				.053	5160	5.71	9.08	8.9	1.283
	75	760	536	.161	22730	4.19	6.66	7.5	1.117
	75	1211	558	.585	15030	6.13	9.72	8.8	1.393
			560	.568	15030	5.97	9.47	8.8	1.356
			561	.566	15030	5.96	9.45	8.8	1.354
			561	.564	15030	5.95	9.43	8.8	1.352
72	15	760	528	.063	5960	7.56	12.03	9.3	1.625
				.057	5960	6.91	11.00	9.3	1.486
	75	761	534	.163	24380	4.00	6.36	7.8	1.025
				.157	24380	3.84	6.11	7.8	0.984
	150	734	538	.206	56570	3.05	4.85	7.0	0.871
	75	1031	546	.370	18530	4.48	7.11	9.2	0.973
			547	.384	18530	4.65	7.39	9.2	1.011
	75	1206	559	.513	13850	5.00	7.94	9.9	1.010
			560	.521	13850	5.09	8.07	9.9	1.028

*Interpolated for corresponding Re_θ

TABLE 3

SUMMARY OF FRICTION BALANCE DATA AND COMPARISON WITH EMPIRICAL RELATIONS

$\bar{x}$ inches	P_o psia	T_o °R	M_δ	θ inches*	Re_θ	T_w/T_{aw}	$C_{f_B} \times 10^4$	$C_f \times 10^4$ (1)	$C_f \times 10^4$ (2)	$C_f \times 10^4$ (3)	$C_f \times 10^4$ (4)	$C_f \times 10^4$ (5)	$C_f \times 10^4$ (6)
48	150	740	4.73	.0719	36500	.77	8.85	7.04 (20.4)	8.03 (9.3)	7.70 (13.0)	8.50 (4.0)	9.18 (-3.7)	7.22 (18.4)
48	135	755	4.72	.0718	32000	.75	8.95	7.25 (18.9)	8.31 (7.1)	8.04 (10.1)	8.76 (2.1)	- -	7.38 (17.5)
48	120	758	4.71	.0735	29000	.75	9.06	7.44 (17.9)	8.49 (6.3)	8.28 (8.6)	8.93 (1.4)	- -	7.47 (17.5)
48	105	762	4.71	.0741	25500	.75	9.34	7.68 (17.8)	8.71 (6.8)	8.58 (8.2)	9.15 (2.0)	- -	7.59 (18.8)
48	90	762	4.71	.0756	22300	.75	9.45	7.94 (16.0)	8.90 (5.8)	8.87 (6.2)	9.37 (0.9)	- -	7.69 (18.6)
48	75	762	4.73	.0775	19100	.75	9.61	8.28 (13.9)	9.17 (4.7)	9.24 (3.8)	9.65 (-0.4)	10.28 (-6.9)	7.83 (18.6)
48	60	760	4.69	.0806	16000	.75	9.91	8.66 (12.6)	9.44 (4.7)	9.66 (2.5)	9.96 (-0.5)	- -	7.97 (19.6)
48	45	762	4.68	.0845	12600	.75	10.38	9.21 (11.3)	9.86 (5.0)	10.29 (0.8)	10.43 (-0.5)	- -	8.18 (21.2)
48	30	762	4.64	.0913	9250	.74	10.61	10.02 (5.6)	10.50 (1.1)	11.22 (-5.7)	11.14 (-5.0)	- -	8.50 (19.9)
48	15	762	4.55	.1037	5470	.74	11.34	11.62 (-2.5)	11.76 (-3.7)	13.09 (-15.5)	12.58 (-10.9)	13.92 (-22.8)	9.11 (19.7)
48	75	1032	4.79	.1071	15800	.56	10.98	7.94 (27.7)	10.56 (3.8)	10.66 (2.9)	10.44 (4.8)	- -	8.67 (21.0)
48	75	1208	4.79	.1200	14000	.48	11.25	7.88 (30.0)	11.54 (-2.6)	11.65 (-3.5)	11.02 (2.0)	- -	9.28 (17.5)
60	150	762	4.75	.0779	37500	.74	7.14	6.91 (3.2)	8.10 (-13.5)	7.73 (-8.4)	8.51 (-19.7)	8.82 (-23.6)	7.27 (-1.8)
60	135	759	4.74	.0800	35000	.74	7.23	7.04 (2.6)	8.19 (-13.3)	7.87 (-8.8)	8.61 (-19.1)	- -	7.32 (-1.2)
60	120	762	4.74	.0822	31800	.74	7.17	7.22 (-0.6)	8.34 (-16.3)	8.07 (-12.6)	8.76 (-22.2)	- -	7.40 (-3.2)
60	105	762	4.73	.0849	28500	.74	7.29	7.41 (-1.6)	8.50 (-16.6)	8.29 (-13.7)	8.93 (-22.5)	- -	7.48 (-2.6)
60	90	762	4.72	.0875	25600	.74	7.26	7.64 (-5.3)	8.70 (-19.9)	8.57 (-18.0)	9.14 (-25.9)	- -	7.59 (-4.5)
60	75	762	4.71	.0916	22500	.74	7.46	7.91 (-6.1)	8.92 (-19.6)	8.88 (-19.0)	9.37 (-25.7)	9.88 (-32.5)	7.70 (-3.3)
60	60	762	4.71	.0940	18400	.74	7.61	8.31 (-9.1)	9.22 (-21.2)	9.33 (-22.6)	9.70 (-27.4)	- -	7.86 (-3.2)
60	45	760	4.69	.0970	14500	.74	7.96	8.87 (-11.4)	9.65 (-21.2)	9.95 (-25.9)	10.18 (-27.8)	- -	8.08 (-1.5)
60	30	762	4.64	.0998	10100	.74	8.31	9.78 (-17.6)	10.39 (-25.0)	11.02 (-32.6)	10.98 (-32.1)	- -	8.45 (-1.6)
60	15	762	4.57	.1060	5550	.74	8.59	11.50 (-33.9)	11.73 (-36.6)	13.04 (-51.8)	12.50 (-45.7)	13.32 (-55.1)	9.10 (-5.9)
60	75	1032	4.80	.1223	18000	.55	8.43	7.65 (9.1)	10.38 (-23.2)	10.35 (-22.9	10.23 (-21.4)	- -	8.59 (-1.9)
60	75	1212	4.84	.1376	15600	.47	8.84	7.84 (11.3)	11.50 (-30.1)	11.65 (-31.8)	10.98 (-24.2)	- -	9.15 (-3.5)

(1) Winkler-Cha
(2) Falkner (ref. enth.)
(3) Blasius (ref. enth.)
(4) Spalding-Chi (1964)
(5) Persh
(6) eqn. in Fig. 18

*INTERPOLATED FROM PROFILE MEASUREMENTS FOR CORRESPONDING Re/ft AT THE SAME X

**NUMBERS IN PARENTHESES ARE FOR VALUES OF $\left(\frac{C_{f_B} - C_f}{C_{f_B}} \times 10^2\right)$

TABLE 3 CONTD

$\bar{x}$ inches	P_o psia	T_o °R	M_δ	θ inches*	Re_θ	T_w/T_{aw}	$C_{f_B} \times 10^4$	$C_f \times 10^4$ (1)		$C_f \times 10^4$ (2)		$C_f \times 10^4$ (3)		$C_f \times 10^4$ (4)		$C_f \times 10^4$ (5)		$C_f \times 10^4$ (6)	
72	150	762	4.72	.0875	42800	.73	7.22	6.71	(7.0)	8.03	(-11.2)	7.57	(-4.9)	8.40	(-16.5)	8.70	(-20.6)	7.23	(-0.2)
72	135	755	4.72	.0888	39700	.74	7.36	6.85	(6.9)	8.09	(-10.0)	7.68	(-4.4)	8.49	(-15.4)	-	-	7.26	(1.2)
72	120	769	4.72	.0909	35000	.72	7.73	7.03	(9.1)	8.35	(-8.0)	8.00	(-3.5)	8.71	(-12.8)	-	-	7.41	(4.1)
72	105	766	4.72	.0928	31500	.73	7.68	7.23	(5.9)	8.49	(-10.4)	8.20	(-6.8)	8.37	(-15.4)	-	-	7.48	(2.6)
72	90	763	4.71	.0955	28000	.73	7.73	7.46	(3.46)	8.66	(-12.1)	8.45	(-9.4)	9.06	(-17.2)	-	-	7.57	(2.0)
72	75	762	4.71	.0977	24000	.73	7.79	7.76	(0.3)	8.88	(-14.0)	8.78	(-12.8)	9.30	(-19.4)	9.72	(-24.8)	7.69	(1.3)
72	60	762	4.71	.1018	19900	.73	8.04	8.12	(-1.0)	9.17	(-14.0)	9.21	(-14.5)	9.60	(-19.4)	-	-	7.84	(2.5)
72	45	762	4.72	.1064	15600	.73	8.18	8.62	(-5.4)	9.53	(-16.5)	9.77	(-19.4)	10.01	(-22.4)	-	-	8.02	(2.0)
72	30	762	4.69	.1132	11200	.73	8.89	9.41	(-5.9)	10.17	(-14.5)	10.70	(-20.4)	10.71	(-20.5)	-	-	8.34	(6.1)
72	14.7	765	4.63	.1253	6200	.72	8.50	11.01	(-29.5)	11.43	(-34.4)	12.60	(-48.2)	12.13	(-42.6)	13.08	(-53.8)	8.96	(-5.3)
72	75	1032	4.76	.1330	19900	.54	9.15	7.46	(18.4)	10.41	(-13.8)	10.27	(-12.3)	10.18	(-11.3)	-	-	8.63	(5.7)
72	75	1212	4.77	.1493	17500	.47	9.63	7.43	(22.9)	11.25	(-16.8)	11.13	(-15.5)	10.69	(-10.9)	-	-	9.16	(4.9)
72	75	590	4.75	.0740	28000	1.00	7.23	8.01	(-10.8)	7.26	(-0.4)	7.26	(-0.4)	8.22	(-13.0)	-	-	6.75	(6.6)
94	150	755	4.66	.0997	50200	.74	7.19	6.52	(9.3)	7.92	(-10.1)	7.35	(-2.2)	8.28	(-15.2)	8.52	(-18.5)	7.17	(0.2)
94	135	762	4.68	.1025	45800	.73	7.26	6.63	(8.8)	8.03	(-10.5)	7.51	(-3.4)	8.39	(-15.4)	-	-	7.24	(0.4)
94	120	762	4.68	.1058	42000	.74	7.30	6.78	(7.2)	8.12	(-11.2)	7.66	(-4.8)	8.49	(-16.3)	-	-	7.29	(0.3)
94	105	758	4.68	.1084	38100	.74	7.36	6.97	(5.3)	8.24	(-12.0)	7.83	(-6.5)	8.63	(-17.3)	-	-	7.35	(0.1)
94	90	760	4.68	.1129	33800	.74	7.33	7.18	(2.1)	8.40	(-14.6)	8.07	(-10.1)	8.80	(-20.0)	-	-	7.43	(-1.4)
94	75	762	4.68	.1185	29500	.74	7.60	7.43	(2.3)	8.61	(-13.2)	8.36	(-10.0)	9.01	(-18.6)	9.52	(-25.2)	7.55	(0.8)
94	60	762	4.69	.1248	24700	.73	7.72	7.73	(-0.1)	8.88	(-15.1)	8.75	(-13.4)	9.29	(-20.4)	-	-	7.69	(0.4)
94	45	762	4.69	.1348	20000	.74	7.71	8.16	(-5.9)	9.16	(-18.9)	9.19	(-19.3)	9.61	(-24.7)	-	-	7.83	(-1.6)
94	30	762	4.67	.1480	14800	.73	7.85	8.82	(-12.4)	9.73	(-24.0)	10.00	(-27.4)	10.22	(-30.1)	-	-	8.13	(-3.5)
94	14.7	762	4.61	.1749	8800	.73	9.02	10.15	(-12.6)	10.81	(-19.8)	11.57	(-28.3)	11.39	(-26.3)	12.72	(-41.0)	8.66	(4.0)
94	75	1032	4.73	.1670	25400	.55	8.54	7.10	(16.8)	9.97	(-16.7)	9.64	(-12.9)	9.79	(-14.6)	-	-	8.39	(1.7)
94	75	1216	4.75	.1925	22700	.47	9.31	7.01	(24.7)	10.78	(-15.8)	10.44	(-12.1)	10.26	(-19.2)	-	-	8.92	(4.2)

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13. ABSTRACT

The results of a detailed experimental investigation of a two-dimensional turbulent boundary layer at zero-pressure gradient are presented. The studies were made at the free-stream Mach number of 5, momentum-thickness Reynolds number from 4800 to 56,000 and wall-to-adiabatic-wall temperature ratios from 0.5 to 1.0. The data are in analytical terms of velocity profile, temperature profile, law-of-the-wall, velocity-defect law and incompressible form factor. Comparisons of local skin-friction coefficients obtained by four different experimental methods are shown. An empirical equation was derived from the shear-balance data to calculate the friction coefficient from known values of Mach number, heat transfer and Reynolds number. ( )

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3. Turbulent						
4. Profile						
5. Pressure gradient						
6. Velocity						
7. Skin friction						
8. Mach number						
9. Temperature ratio						
10. Reynolds number						

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